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THE EVOLUTION OF THE LAMP.

By Edgar James Banks,* Ph. D.

The Oriental lamp is the same now as it always has been—a simple dish of clay, stone, bronze or glass, filled with oil; its wick is a rag or a twist of cotton, one end of which is immersed in the oil and the other rests over the edge of the dish to be lighted. This was the lamp not only of ancient Babylonia and Egypt, but also of the Hebrews, Greeks, Romans and all other early peoples. It is still the common lamp of Mesopotamia. Even in Saint Sophia, the great mosque of Constantinople, there is no other method of illumination.

The first artificial light with which primitive man illuminated the darkness of night was the camp fire, the same fire with which he warmed his naked body and roasted his meat. Just the age when the idea of lighting the darkness by other means first occurred to him, is no longer known, but the excavations at the Babylonian mound, Bismya, the ruin of the oldest known city in the world, have shown that it was long ago, perhaps thousands of years before 4500 B. C.

During the excavations far beneath a temple which was constructed at that remote date, among the ruins of earlier ages, there was found a large conch shell about 8 ins. in length. Its exterior had been worn smooth by constant handling, and a section at its opening, and half of its elongated valve had been cut away so that it formed a deep dish terminating in a long snout. In its interior were slight traces of a thin, black deposit. At first the use for which this dish was intended was puzzling; it was weeks later when it suddenly occurred to me that this sea-shell was the primitive lamp, the ancestor of the great family of lamps.

Some time later, while excavating at a higher level in the temple refuse heap, where the priests of 4500 B. C. threw the broken and discarded utensils of the temple service, there appeared among the dozens of baskets full of polished and cut stone, several triangular objects which resembled the conch shell in shape. One of alabaster was entire; others were fragmentary, yet their original forms could be restored. They were the lamps which came into vogue after the conch had passed away, or when it became so scarce that it was no longer employed, and stone was substituted in its place. Although the conch was discarded, its triangular form remained, even to the natural snout for the support of the wick, which was reproduced in the stone.

To the early Babylonian, the pure, almost transparent alabaster lamp was perfect in shape; the next step in the evolution was in its decoration. Instead of the plain exterior, it was engraved with reticulated or curved lines; but a more important step in its decoration was when the lamp-maker conceived the idea of supporting the wick in a hole at the sharp corner of the lamp. One such example from the Bismya temple refuse heap terminated in a ram's head, and the lighted end of the wick projected from its open mouth. After the discovery of the hole for the wick, it was an easy step to cover the entire lamp, with the exception of an opening in the center to receive the oil. Thus the lamp of classical times originated. Another interesting example from Bismya is an extremely large marble lamp, oval in shape and with vertical walls. The snout for its wick is a deep groove extending out about 2 ins., and with its support from beneath it resembles the handle of a modern dish. This lamp held about two quarts of oil, and, as it was found in the ruins of the temple, its unusual size suggests that in the Babylonian temple, as in the synagogue of a later era, and in some churches, even to the present day, a light was kept perpetually burning.

Previous to 4000 B. C., the lamps, as well as most dishes and household effects, were of stone; after that time objects of burned clay began to appear. Before that date lamps were found only in the ruins of the temple; later the clay lamps were found in the dwelling houses of the people.

Fig. 1. Ancient Conch Shell. The Earliest Lamp of Primitive Man.

Fig. 2. Alabaster Lamp, with Curved Snout for Supporting the Wick.

Fig. 3. Alabaster Lamp of About 4500 B. C. (1-3 Natural Size.)

Fig. 4. Clay Boat-Shaped Lamp of About 3800 B. C.

Fig. 5. Triangular Clay Lamp with Animal's Head.

Fig. 6. Marble Lamp with Ram's Head. (The Wick Came Through the Mouth.)

Fig. 7. Decorated Marble Lamp.

FIG. 8. LAMPS OF LATE BABYLONIAN AND PERSIAN PERIODS.
1. Modern Bagdad Lamp Purchased in the Market.
2. Blue Glazed Lamps of Early Arabic or Persian Times.
3. Common Roman and Greek Lamps Found in all Ancient Countries.

*Field Director of the recent Babylonian expedition of the University of Chicago, Hotel Hayes, Chicago, Ill.

Of the latter a variety of shapes have appeared. Some are triangular, the shape suggested by the conch; one is a miniature boat; others of a later period are identical in shape and size with those of Rome and Greece. The lamp of these nations was undoubtedly borrowed from the older civilization of Babylonia. The common clay lamp of Persia and of the time of Haroun er Raschid assumed a round form with a dent in its rim for the wick, resembling in every respect a miniature frying pan, from which the handle is missing. The lamp of modern Bagdad differs from it only in being set upon a pedestal and provided with a handle.

It remained for the lamp maker of the civilized West, who would no longer rest the wick upon the edge of the receptacle for the oil, to pass it through the brass arrangement which he called the burner, and to provide it with a screw that it might be raised or lowered, and the essentials of the modern oil lamp were assembled.

While we have the sea-shell, the lamp of primitive man of over 6,000 years ago, it would be interesting to know what kind of oil was burned in it. The olive tree produces the illuminating oil of the modern Orient, and although in other parts of the world the fat of animals was used, the unchanging customs of the East lead us to infer that olive oil was also then employed. The wick was doubtless a twist of the cotton which grows wild along the shores of the Tigris and the Euphrates.

REINFORCED CONCRETE FILTER BED WALLS AND ROOFS, INDIANAPOLIS, IND.

By William Curtis Mabee.*

Reinforced concrete slab and girder roofs have been constructed during the last year for two of the open filter beds of the Indianapolis Water Co., at Indianapolis, Ind. These open filter beds were each 1.6 acres in area, and there were three of them. They had been put in operation in 1904. The beds had given trouble in operation on account of both ice and algae growth, and the covering was decided upon as a remedy. As the beds had been found to be too large for economical operation, it was decided to reduce their size at the same time by dividing each into two beds by a partition wall, thus making a plant of six ¾-acre units instead of three 1.6-acre units.

GENERAL DESIGN.

After an inspection of many existing filter plants, reservoirs and their covers, it was determined to adopt a reinforced concrete slab construction, as offering the best and probably the cheapest means of meeting the local conditions, which were rather unusual, inasmuch as the beds had been built without provision for piers to support the vaulting, and were filled with filter sand. Time was also an important element in the selection of the design, as it was thought necessary to cover at least two of the undivided beds before another winter set in, and three if possible. The number and size of the supports was also an important factor, as it was advisable to preserve the filter medium as much as possible.

The customary form of covering for filter beds and large reservoirs is the groined arch or vaulted construction, formerly built of brick, but now of concrete, which is not usually reinforced, and for heavy loads it has distinct advantages. The supports for these structures are concrete pillars, usually about 21 ins. square in their least dimension, and spaced approximately 14 ft. on centers. These intersecting arches make an efficient covering, but are expensive to construct because of the complicated form work of centering. Moreover, the vaulted covers, unless reinforced with steel, are subject to cracks at the crown of the arch.

With vaulted roofs it is the custom to load the roof with 2 ft. of earth, as an insulation against the freezing of water and sand within the filter bed and as a protection for the thin layer of concrete in the arches, the drainage being carried down inside the column or support and discharged at the surface of the sand, thereby causing a disturbance of the sand bed while filtering is in progress. With the covering built in Indianapolis, the drainage of storm water falling upon the roof will be brought to one end of the bed (by sloping the roof) and discharged directly into a drain leading to a sewer.

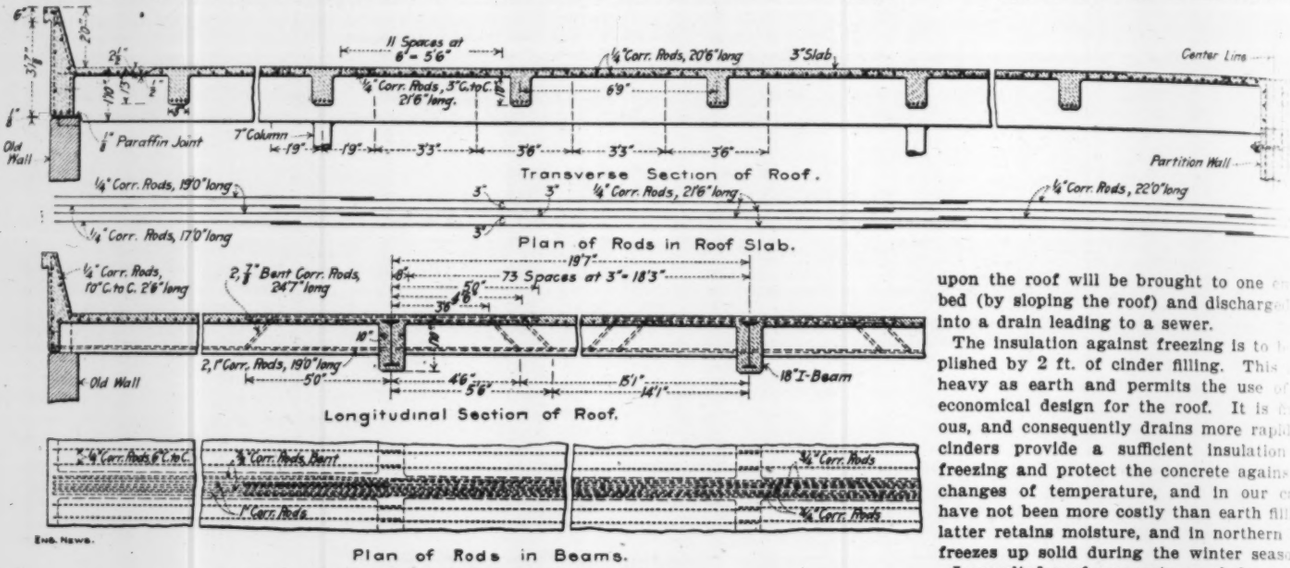
11 Spaces at 6'-5 6"
¼" Corr. Rods, 20'6" long
3" Slab
Center Line
¼" Corr. Rods, 3" C. to C. 2'6" long.
6'9"
1" Paraffin Joint
7" Column
Old Wall
Partition Wall
Transverse Section of Roof.
¼" Corr. Rods, 19'0" long
¼" Corr. Rods, 2'6" long
¼" Corr. Rods, 22'0" long
¼" Corr. Rods, 17'0" long
Plan of Rods in Roof Slab.
¼" Corr. Rods, 10" C. to C. 2'6" long
2, 7/8" Bent Corr. Rods, 24'7" long
73 Spaces at 3"= 18'3"
2, 1" Corr. Rods, 19'0" long
18" I-Beam
Old Wall
Longitudinal Section of Roof.
¾" Corr. Rods
1" Corr. Rods
Plan of Rods in Beams.

FIG. 1. SECTIONS OF ROOF OF FILTER BEDS.

The insulation against freezing is to be accomplished by 2 ft. of cinder filling. This is not so heavy as earth and permits the use of a more economical design for the roof. It is more porous, and consequently drains more rapidly. The cinders provide a sufficient insulation against freezing and protect the concrete against sudden changes of temperature, and in our case they have not been more costly than earth filling. The latter retains moisture, and in northern latitudes freezes up solid during the winter season.

In vaulted roofs concrete manholes are usually provided every 28 ft., and these almost invariably break off at the joining with the vaulting (unless reinforced with steel) by the upheaval of the frost. This causes a constant dripping during certain seasons of the year, which is a source of annoyance to the men working in the bed, besides pitting the sand where the dripping occurs.

In the design as adopted for Indianapolis, the roof consists of a 3-in. concrete slab, supported by concrete beams spaced 6 ft. 9 ins. c. to c., which in turn are carried by steel I-beams encased in concrete, making a main carrying girder 22 ins. deep. These main girders rest upon 7-in. cast-iron columns spaced about 20 ft. c. to c. The base plates of the columns rest upon concrete piers 9 ins. above the filter bed floor. The slab and girder construction is shown clearly by Fig. 1.

The reasons for adopting cast-iron columns in preference to concrete piers was primarily to

FIG. 2. ROOF OF FILTER BEDS UNDER CONSTRUCTION.

*Constructing Engineer, Indianapolis Water Co., Indianapolis, Ind.

save the ... erection and to minimize the disturbance ... the sand layers. The excavation for the ... ns was accomplished by means of light ste... lindrical caissons sunk through the 4 ft. of ... material, the cylinders sinking by their ... eight; this avoided disturbance of the sur... ling sand. Fig. 2 shows a row of these co... s, and two rows of columns erected, while at the right the beams are in place and a portion of the cover or roof completed. The columns, Fig. 3, have flanges for the purpose of baffling the raw water on its passage to the underdrains. The column occupies only about one-twelfth of the space taken by the ordinary square piers in vaulted construction, and in our case only half the number of supports were required, thereby effecting a saving of over 500 sq. ft. of filter surface to the acre. The cast-iron columns are filled with concrete and the outside surface was given two coats of asphalt paint.

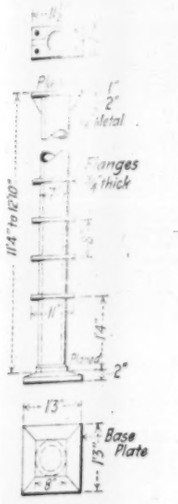

Fig. 3. Cast-Iron Column.

The partition walls are each 350 ft. long, without expansion joints. For nearly their entire length they are anchored to the floor at the bottom and to the roof at the top; hence each wall becomes a vertical slab over 300 ft. long and 14 ft. high, supported along its longer sides. As there will be unbalanced water pressure on either side, it was necessary to design this slab wall with vertical reinforcing bars on both faces. The wall is 12 ins. thick and so reinforced as to limit the stress in the bars to one-fourth the elastic limit of the steel under maximum condition of water and sand pressure. The wall at each end does not extend to the roof, as provision had to be made for entrances and platforms. At these places the walls were designed as gravity dams, capable of resisting by their own weight the overturning forces due to water and sand on either side. The main and gravity sections of the wall are shown in Fig. 4.

As the walls were to be water-tight, it was decided to avoid expansion joints and build them solid from end to end, depending altogether upon the longitudinal reinforcing. This reinforcing is equal to about 1-300 of the cross-section in the main portion of the wall (or what might be termed the web of the beam), about 1-220 in the lower 24 ins., and about 1-70 in the upper 20 ins., which was considered as a horizontal beam between the steel I-beams which intersected the partition wall about every 20 ft. Similar walls, reinforced with corrugated bars to the extent of 1-300 their cross-section had successfully resisted the shrinkage stresses due to temperature changes, notably a 300-ft. retaining wall in Indianapolis, built in 1904, which has no visible contraction cracks.

The theory upon which these walls are reinforced against cracking from shrinkage or temperature stresses is that sufficient steel be supplied so that the elastic strength of the steel will balance the tensile strength of the concrete. Hence, if the elastic limit of the steel is assumed to be 60,000 lbs. per sq. in., and the tensile strength of the concrete is taken at 200 lbs. per sq. in., the ratio of steel to that of the concrete should be as 1 to 300; therefore, 1-300 of the cross-section of the wall is made up of steel bars having an elastic limit of 60,000 lbs. The bars prevent cracks developing, and while the whole extent of the concrete may at times be in a state of tensile stress, tending to crack at all sections, the presence of the steel will prevent any movement of the concrete greater than the elongation of the steel under its corresponding stress, which elongation is, of course, microscopical in short distances.

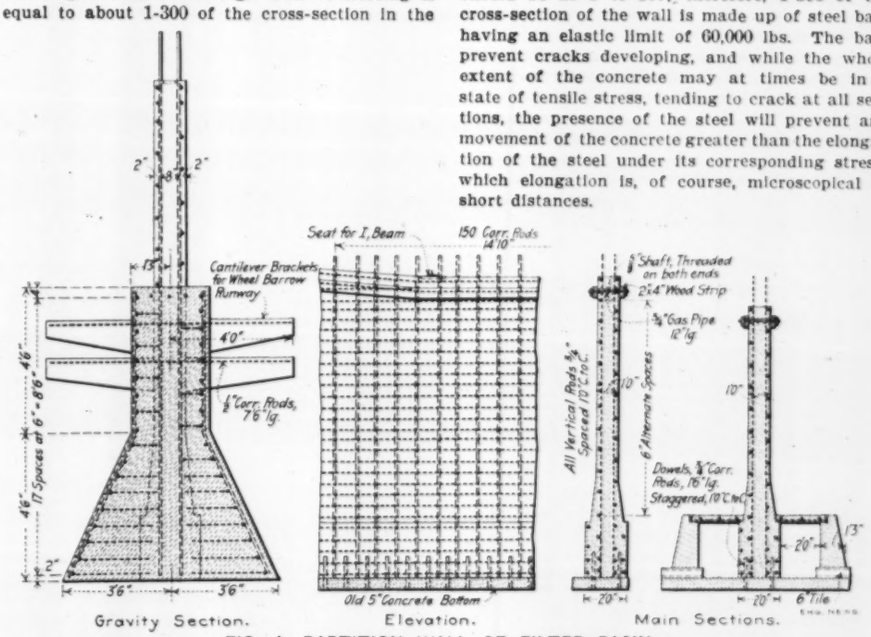

FIG. 4. PARTITION WALL OF FILTER BASIN.

While in a plain concrete wall the shrinkage stresses act until finally a crack occurs, in a properly reinforced concrete wall this state of stress remains until a change of temperature relieves it, and there is no more tendency to crack than there is in a long bar of iron or steel, which will expand or contract if free, or, if held rigidly, will become stressed in tension or compression by change in temperature, but will not break from tension due to atmospheric temperature changes. These walls have demonstrated the correctness of the theory by remaining water-tight, although (as stated) they are each 350 ft. long without expansion joints and have been subjected to a range of temperature equal at least to 70°. Several hair cracks are visible, but they give no trouble, nor do they enlarge. The same method was followed in the design of the covers; that is, 1-300 of the cross-section is of steel.

The roof was designed to carry a filling of cinders 2 ft. deep, with such additional weight of water as the cinders will retain. Ample slope was given to drain the water not retained by the cinders, the slope being made by lengthening the columns. This drainage is carried away by means of perforated pipes extending vertically into the cinders at one end of the structure, and connected to a larger pipe suspended from the roof inside the filter bed and from there conveyed directly to a vertical pipe which also takes the overflow of the raw water from the beds.

The main girders are 18-in., 55-lb. I-beams, continuous across the entire width of two filter beds, and resting upon roller bearings; they are anchored to the partition wall and bolted to the columns. These beams are spliced at the quarter point of the span, the splice being made with two pieces of 15-in. channels and sufficient rivets for transmitting both moment and shear. The concrete beams are designed as continuous beams for the entire length of the filter beds, 350 ft. The details of the reinforcing are clearly shown in Fig. 1. In general, this reinforcing consists of four bars, each bar being so bent that for three-quarters of its length it is near the bottom of the beam, and then passes along the top of the beam and over the top of the I-beam for about a quarter span; hence each bar has a length of approximately 1¼ times the length of the beam. There are four bars near the bottom at the center of the beam, and four bars near the top over the main girders, providing for the tensile stresses in a continuous beam over 19 supports. The bars were all shipped straight and of the required length, and bent cold in a railway frog. These

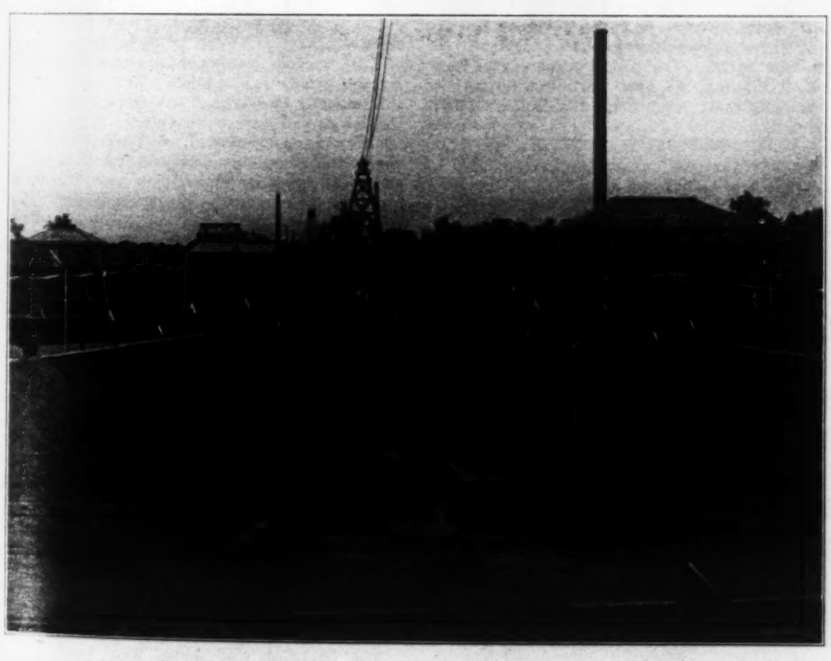
FIG. 5. END VIEW OF ROOF OF FILTER BED UNDER CONSTRUCTION.
(The new high parapet wall rests on the old low parapet wall. In the center is the new partition wall, with cantilever brackets for runways.)

long continuous beams rest upon the end walls and upon a lubricated joint, consisting of two sheets of galvanized iron with a thin layer of grease between to allow play for the shrinkage and expansion of the beams without introducing a bending strain upon the supporting walls.

About the four sides of the double filter and anchored to the beams and floor slab there is a parapet wall for retaining the cinders and for closing the spaces between the beams; this wall is kept separate from the main supporting walls by a 1/8-in. paraffin joint, made by pouring hot paraffin upon the supporting walls for their entire length. This paraffin had a melting point of 125° F. The purpose of this joint is to allow the monolithic cover to expand and contract without introducing bending into the supporting walls. In short, this entire area of 70,000 sq. ft., or 1.6 acres, is without expansion joints of any kind, and is independent of the supporting structures except at the dividing wall. The parapet walls and the roof are raised at the end to give room for entrances, as shown in Fig. 5. This view also shows the steel main beams and the central partition wall with cantilever brackets to support runways for wheelbarrows in handling filter sand. The original parapet wall for the open basin will be seen extending a little above the concrete walk; the new concrete wall rests upon this, being separated from it by a paraffin joint, as already explained.

In the design of the roof, since the loads were quiescent and definite in amount, a factor of safety of three was adopted, based upon an elastic limit in the steel of 50,000 lbs. per sq. in. and using 1% reinforcement.

METHODS OF CONSTRUCTION.

The centering was designed to be entirely supported by the columns and the steel girders, with shores under the centers of the beams simply to reduce the deflection and add stiffness. Inverted U-bolts were used to suspend the beam boxes from the I-beams, and small cast-iron blocks were placed under these beams where the loop hangers were used, so that the nuts on the bolts could be turned up to a firm bearing and the forms securely held in position during the placing of the concrete. These are shown in Fig. 6. In order to space the beam bars properly and hold them off from the sides and bottom of the beam forms, special blocks were made of sand and cement with a couple of wires embedded as reinforcing. These blocks, also shown in Fig. 6, like the cast-iron blocks, remain permanently in the work. All edges of the beams were battened off by the introduction of a triangular strip tacked into the beam forms at the intersection of the sides with the bottom and top. The forms were of 2-in. dressed and straightened lumber, and struts and joists, 2 × 4 ins., connected them. Dressed boarding, 1 × 6 ins., was used for the slab centering. The centering was so put together that it could be taken down without injury and used over and over again.

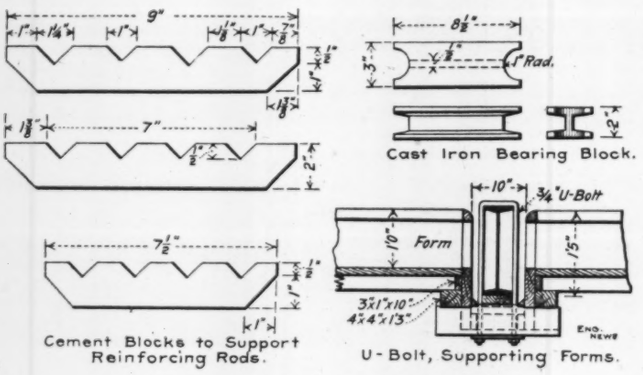

FIG. 6. U-BOLTS AND BLOCKS FOR FORMS.

Where the beam forms intersected over a support they were held up by wooden clamps bolted to the columns. These forms were given a slight camber at the center by the shores already referred to. The bars were placed in their proper position and securely wired together, to prevent them from being disturbed while placing the concrete about them.

All concrete was mixed in a batch machine and placed very wet. It was then leveled off with a 16-ft. straight edge, no troweling being done. No plastering was necessary, as the concrete presented a smooth and uniform appearance when the molds were removed. For several days the concrete was kept moistened by spraying it with a hose. The centering was also wet down before beginning work for the day, for the purpose of swelling the lumber and tightening the joints. From 10 to 14 days, and occasionally three weeks, elapsed before the centering was removed. The proper time was determined by tapping the new work lightly with a hammer and also observing the color; when sufficiently set, the concrete gave a metallic ring under the hammer. After the floor slab and beams had been finished and the forms removed, the parapet wall forms were set up, resting upon the supporting walls and the concrete deposited upon the paraffin joint.

A cableway, 450 ft. long, suspended from movable cable towers mounted on tracks was used for the erection of the columns and I-beams, and also for the placing of all concrete. This is shown in Fig. 5. The concrete mixer remained in one position during all the work on the double filter bed, the concrete being taken from the mixer in buckets carried upon a small car which was hauled between the mixer and the cableway by means of a cable passing over a pulley and operated by a small reversing engine.

The sand and gravel for the concrete as well as for the filter material, was dredged from Fall Creek at the filter site by means of an orange-peel dredging machine and gravel pump mounted on scows. All the material was thoroughly washed and screened. No gravel larger than a ¾-in. sphere was used in the concrete of the beams and slab, and none larger than 1½ ins. in the dividing and supporting walls. The mixture for the beams and slab was 1 : 2 : 4, while that for the walls was 1 : 3 : 4, there being 0.617 cu. yds. of concrete per sq. ft. of surface. The concrete on the covers proceeded at the rate of over 80 cu. yds. a day, covering nearly 5,000 sq. ft. of surface. At the joining of each section the edge of the concrete was swept clean, and a wash of cement grout was applied. The bars extending continuously throughout the work prevented any shrinkage and gave a water-tight joint.

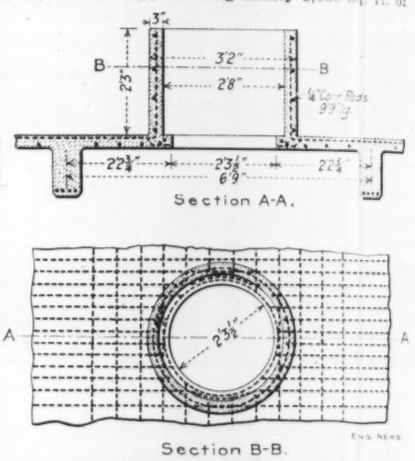

Fig. 7. Manhole in Roof of Filter Bed.

Three manholes, Fig. 7, were provided for each cover, reinforced by rods bent up from the roof slab. A dead air space was provided in each manhole by placing a removable galvanized-iron sheet in the bottom and a cast-iron frame and cover on the top of each. Short pipe nipples were built into the beams for attaching electric fixtures used in lighting the interior when cleaning or scraping a filter bed. The manholes and entrance doorways furnish a circulation of fresh air. Clamps for pipe hangers were fastened to the I-beams from which the wash water and sand line piping was suspended, the purpose of which is to remove the dirty sand by the hydraulic process. It is proposed to pass the sand through a portable sand washing device by means of a portable Korting ejector, depositing it by hydraulic means into concrete bins located at each entrance. Two entrances are provided for each filter bed, as shown. In recharging, the sand will be wheeled down the inclined platforms at either end of the filter bed from these storage bins. This arrangement eliminates one objectionable feature of most filter plants, namely, the storage of sand in promiscuous heaps about the sand courts.

The partition wall forms were made of 2-in. dressed and straightened lumber, nailed to 4 × 4 posts, set up in pairs, 4 ft. apart. One side of the wall form was braced and the other wired to

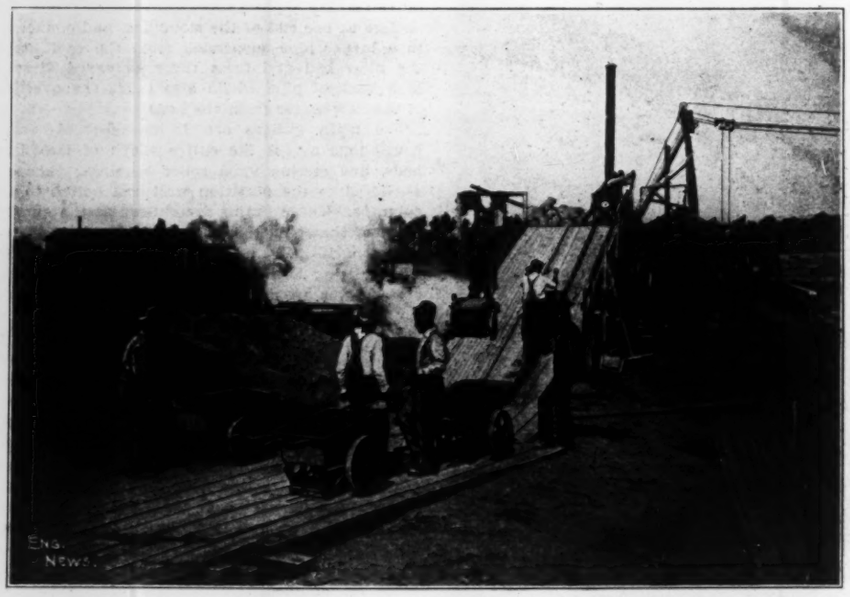

FIG. 8. CONCRETE PLANT, WITH SPROCKET CHAIN FOR HAULING WHEELBARROWS.

FIG. 9. TOP OF ROOF OF FILTER BED READY FOR THE CONCRETE.

it, both sides being boarded up to the top and held apart by wooden struts, which were removed as the concreting progressed. The bars were all placed in position and securely wired together after one side of the wall forms had been built up and before any concrete was placed. The spacing of the vertical bars was kept uniform and the alinement straight by means of wooden templates fastened at the top of the wall, having holes drilled at proper intervals, through which the bars were dropped; this held them securely while the horizontal bars were being wired to them. A temporary platform was built of staging alongside the wall for convenience in placing the bars and concrete.

A movable hopper on wheels was mounted on a wooden track, fastened to the 4 × 4 posts, into which the bottom dump buckets dropped their load, the hopper deflecting the concrete into the narrow wall. The concrete, being very wet, was simply churned in the forms with long sticks to bring the cement to the face. After removing the forms, the wires were clipped off close to the wall, and nothing further was done to it, the surface being fairly smooth. Runways for wheeling sand into the filter beds are supported by cantilever beams extending on either side of the partition walls at the entrances (Fig. 5).

The sand and gravel was brought by locomotive and cars on a narrow-gage track to a point near the mixer and loaded into special balanced wheelbarrows of 5 cu. ft. capacity. An endless chain, passing over sprocket wheels, engaged with a hook on the bottom of these barrows and took them up an inclined platform to the mouth of the mixer, as shown in Fig. 8. Definite amounts of water were delivered into the mixer with each batch by means of a quick-opening valve attached to a barrel, into which a small stream was constantly flowing. Fig. 9 shows a view of a portion of the slab roof and girders ready for the concrete.

COST.

Not including the dividing walls and supporting walls, but including the columns and parapet walls, the roofs have cost thus far 35½ cts. per sq. ft. This includes a liberal charge against depreciation of lumber and equipment, but does not include superintendence. The work was all done by the employees of the water company, great care being exercised to carry on the work strictly in accordance with the plans and to insure good workmanship throughout. The plans for the filter roofs were prepared by Theo. L. Condron, M. Am. Soc. C. E., of Chicago.

Work began on the covering of bed No. 1 on June 3 and was completed Aug. 30, 1905, the other two filters being in continual operation. On Sept. 5, 1905, work began on bed No. 2, which was completed and put in service again on Nov. 17. Bed No. 3 is still to be covered, and the work will be done as soon as the weather permits.

UNDERWRITERS' COMMITTEE OF TWENTY ON FIRE PROTECTION IN NEW YORK, CHICAGO AND DETROIT.

The National Board of Fire Underwriters, through its Committee of Twenty, is making a series of reports on the fire protection of some of the larger cities of the country. Each of these reports follows a carefully worked out plan, taking up first the city in general; then its fire fighting facilities, including the water supply, fire department, fire alarm service and fire department auxiliaries; then structural conditions and hazards, including the building department, explosives and inflammables, electricity, congested value districts and conflagration hazards; and detailed recommendations in the order named, followed by a brief summary. Mr. S. H. Lockett is Secretary to the Committee, with offices at 135 William St., New York. Mr. F. F. Moore is Hydraulic Engineer. Mr. J. W. DuB. Gould was engineer in charge of the hydraulic work in New York and Mr. Geo. W. Booth had charge of the party and of the hydraulic work in Chicago and New York. Various other engineers and experts are connected with the work of the committee and took part in the several investigations. Three reports have been published recently, dealing with the Boroughs of Manhattan and the Bronx, New York City, with Chicago and with Detroit, and comprising 98, 75 and 52 pages, respectively, besides folding maps and tables. Some information from these reports will be given herewith, relating more especially to water supplies.

MANHATTAN AND THE BRONX, NEW YORK CITY.

Until recently the records and plans of the distribution system were "very incomplete and in some respects almost entirely lacking." Under the present Chief Engineer, Mr. I. M. de Verona, M. Am. Soc. C. E., field surveys have been made and from these plans on a large scale are being drawn, showing the location of mains, gates and hydrants and other essential information. A record of gate valves, begun in 1902, has not been kept up during the past year. Records of pumping, consumption and pressure have not been kept in form convenient for ready reference, but notable improvements in them have been made of late. There are "no reliable records showing the daily consumption" of water. The gagings heretofore made of the delivery of water through the Croton aqueduct have been in some respects unsatisfactory, but the chief engineer has recently placed an assistant in charge of this matter.

The maximum rate of water consumption occurs about 10 a. m., when it is 19% above the mean rate for the day. The minimum rate is 82% above the mean, and occurs at about 3 a. m. About 20% of the taps are metered, but the meter rates are such as to "discriminate against the use of meters."

Recording pressure gages are located in the headquarters of six repair companies in different parts of the two boroughs, but "records from these gages are not properly filed and many are reported lost."

The repair gangs on the distribution system have until recently been very loosely organized, as has been shown by the length of time required to begin operations at several breaks in large mains. Lately, however, the gangs have been reorganized. There is a lack of cooperation between the Fire and Water Departments, in the matter of breaks in the mains. With the exception of minor repairs, the Water Department is dependent upon private shops. The city, the report states, is not equal in emergency methods, repair shops and the like, to the corporations operating public service utilities within the city.

Almost all the 11,591 valves of 4 ins. and over are "of an antiquated department design." The spacing of valves is, to a large extent, excessive. The smaller valves "are in general in very poor condition."

An inspection of more than 1,000 fire hydrants distributed over the two boroughs showed that "in general their condition was found to be unsaitsfactory. Many were hard to operate, leaky, badly worn and otherwise out of order." In testing hydrants in groups of six, "it was found that the discharge from some or all of such outlets [4½-in.], with all outlets in the group open, was too feeble to be measurable with the testing apparatus."

As to the adequacy of the water supply of the city, the report states:

> In view of the fact that the present, and steadily increasing, rate of consumption exceeds the safe yield of the Croton system as developed by 23,000,000 gals. per day, there is a grave danger overhanging the city of a water famine, which would be certain if a series of dry years should occur before additional supply is secured. The recent years of high rainfall have caused a want of appreciation of the seriousness of the situation, as evidenced by the dilatory methods with respect to emergency development.

On the subject of per capita consumption, the report states that, although it is not abnormally large compared with other large cities, yet the "question of waste and leakage needs more study, especially as regards the specific cause or causes of the excesively high minimum night rate." Any possible stoppage of waste, however, "would not lessen the urgency of securing additional supply at the earliest possible date."

The incompleteness of pumping records indicates "an inefficient operation and maintenance."

Regarding the Fire, Department, the report states that throughout the larger part of the two boroughs the force is efficient, but "through the power of numbers rather than through the efficiency of individual companies, for the latter are equipped generally with engines of only moderate size, not always in good condition and frequently poorly handled." The per capita expenses of the department are low. The salaries paid the members of the force "are unusually large and attract a class of men who make, with comparatively few exceptions, able and brave firemen."

Taking up next the structural conditions and hazards, the report states that an inspection of a large number of buildings under construction showed that in structures of the higher grades the regulations were being enforced, but that there was much laxity as regards cheap tenements and apartments.

Although the building laws are comprehensive, they are lacking in many particulars. Thus:

> The provisions relating to structural iron and steel work are inelastic and those pertaining to concrete steel do not wholly recognize the advance of the art. Cast-iron columns united end to end at each floor by flanges are permitted without height restriction. No distinction

is made between private dwellings and dwellings for apartment purposes or between joisted and mill construction. Heights and areas are not restricted in accordance with modern views. Nor are the provisions adequate with respect to protection on wall and floor openings, thickness of walls in certain types and thickness of masonry demanded between ends of floor beams on opposite sides of walls. The responsibility for enforcing the fire escape ordinances is divided between several departments, and the fire limits could be extended to advantage.

The conflagration hazard is most seriously affected by the size and hollow square formation of the blocks, making them in effect single risks in many cases; the large number of conflagration breeding blocks; . . . the narrow streets and general absence of fire breaks in connection with the average great height of buildings; the frequency of unprotected vertical and horizontal openings, particularly excess-height openings; the high winds; the practically uniform inability of the water distribution system to supply the demands of third-alarm fires; the physical conditions interfering with the proper handling of the Fire Department apparatus; and the antiquated, deteriorated and unreliable fire alarm system.

[A separate report has been made by a committee of the Board of Fire Underwriters on the fire alarm system of Manhattan, showing that it is in a deplorable condition. A proposal for a large appropriation to make good the defects in the system is now under consideration by the city government.]

FINAL RECOMMENDATIONS.—The extension of the separate fire main system already authorized for a part of the city should be made as rapidly as possible throughout a large part of Manhattan, and steps should be taken to raise the minimum pressure in the Bronx and portions of Manhattan not provided with the separate fire mains, so as to give minimum pressures of 70 lbs. and upwards. Mains supplying fire hydrants should not be less than 8 ins. in diameter, even in outlying residence districts, while in mercantile, manufacturing, warehouse, lumber and congested residence districts such mains should be in general not less than 12 ins. in diameter. Immediate steps should be taken to replace by 8-in. mains all mains not more than 4 ins. in diameter now supplying fire hydrants. Where a 6-in. distribution system now prevails in residence districts larger mains should be inserted "into the gridiron in such manner that all 6-in. mains will be fed by the larger sizes at intervals not exceeding 500 ft."

For the prevention of waste the city should be permanently districted

and work energetically continued at once to determine the distribution of the waste, with particular attention to the cause of the unusually high rate of minimum night flow. As the most effective way of reducing the large waste from defective plumbing and fixtures, a more general use of meters on services [should] be encouraged by a proper readjustment of meter rates; the intelligent application of a policy of metering first the larger unmetered services, with the eventual extension of meters to all services cannot fail to accomplish the desired result, as has been amply demonstrated by experience elsewhere.

The electrolysis of water mains should be investigated, particularly in the Bronx, and systematic electrical surveys should be made from year to year.

Additional gates should be installed wherever more than 500 ft. of mains would be affected by a single break.

The future installation of hydrants, except on separate fire mains, should be in accordance with the following specifications:

(1) All hydrants in districts other than those of a strictly residence character to have at least two 4½-in. steamer outlets, each fitted with independent gate, not less than 8-in. barrel, and connection with main by pipe at least 8 ins. diameter, the latter fitted with gate between street main and hydrant.

(2) All hydrants in strictly residence districts to have at least one 4½-in. steamer outlet and one or more hose outlets, each provided with independent gate, not less than 6-in. barrel, and connection with main by pipe at least 6 ins. diameter, the latter fitted with gate between street main and hydrant.

Pending the construction of the separate fire main service, it is recommended that single 2½-in. outlet hydrants be replaced, in accordance with the above specifications, wherever study of local conditions indicates that larger hydrants would be amply supplied with water. Where careful investigations, as recommended, show that a hydrant will furnish 600 gals. per min., such hydrants should be designated by a distinctive color.

The Fire Commissioner should be "of demonstrated administrative ability and free from active political affiliations." Increased weight should be given to the records of candidates when promotions are under consideration, and "examinations for promotion to the higher positions in the uniform force [should] be non-competitive." An expert mechanical engineer, with necessary assistants, should be appointed supervisor of machinery, with full control of the same and of the engineers and assistants in charge of the steamers. All existing steamer engineers should be thoroughly examined as to ability and none should be retained who are not fully competent.

The building laws of the city should be revised to comply with existing conditions and modern views, using as a guide the building code recently prepared by the National Board of Fire Underwriters; and "the supervision of building construction [should] be a function of the city instead of the separate boroughs."

A complete reinspection of old electric wiring is recommended, with reinspection at suitable intervals and a correction of defects as found. All electrical contractors should be required to take out a license. All wiring inside the fire limits should be placed under ground as soon as practicable. Telephone, telegraph and signaling wires should be placed in separate subways and provided with separate manholes from those used for lighting and power service.

To reduce the conflagration hazard, narrow streets should be widened or adequate window protection provided, or else both methods combined. In all buildings which, on account of size, construction or occupancy, might breed conflagrations, automatic sprinklers should be provided.

CHICAGO, ILL.

Among the general conditions affecting fire protection in Chicago, it is noted that the cedar block pavement, which forms a large proportion of all the paved surfaces of the city, "is almost universally in very poor condition, uneven and badly disintegrated," rendering the rapid passage of fire department apparatus impossible. For the past five or six years no wood blocks have been laid. [It should be understood that the wood block pavements of Chicago are not for a moment comparable in character with those used for many years abroad and during the past few years in this country with eminent satisfaction.] As a rule, either well paved streets or car tracks are available for the fire apparatus by going a few blocks out of the way.

No recording pressure gages are installed on the distribution system of the water-works, with the exception of one at each pumping station.

Tests of 593 fire hydrants, well distributed throughout the city, showed that "only 32% of the hydrants tested gave a free discharge of as much as 600 gals. per min., a fairly satisfactory supply for the second-size fire engines;" while of 560 hydrants "in the main service only 80, or 14%, under the conditions obtaining, will furnish a full supply for a first-size engine." Of the hydrants tested, none with single 2½-in. outlets "yielded enough for more than one good fire stream under the best conditions and many but a fraction of this amount" [for use with steamers].

Although an unlimited supply of water, from Lake Michigan, is available, the

capacity of the present pumping stations is dangerously close to the maximum rate of consumption, but installation of additional machinery may be delayed if stringent measures of waste prevention be instituted. . . . The rate of consumption in this city is unusually large and unless restricted will necessitate costly extensions of the supply works, larger mains in the distribution system and extravagant operating expenditures at the pumping stations. While it is obvious that the per capita consumption for useful purposes in different cities must necessarily vary according to different conditions, and that a considerable waste from leaky mains and plumbing fixtures is probably unavoidable, it has been well established that a consumption much exceeding 100 gals. per capita indicates a large and unnecessary waste, which should be checked, not alone for economic reasons, but on account of its bearing on fire protection. Street mains which are designed to deliver a normal supply to consumers with reasonable margin for emergencies created by fire, are entirely insufficient to meet the demands of the latter when ordinary consumption becomes swollen to an abnormal amount.

The average per capita consumption of water in Chicago for the last four years is reported by the Water Department as increasing gradually from 195 to 204 gals. Of 220,000 services, only about 4%, mostly large consumers, are metered. The city engineer has estimated that 75% of the total pumpage is wasted, and has recommended that at least 40% of all taps be metered.

The pressures are unsatisfactory at [illegible] increased at the pumping stations, [illegible] waste is curtailed, improvements [illegible] distribution system and the prop[illegible] fire main service installed. The ty[illegible] in use is generally unsatisfactory, [illegible] the size and number of outlets (mo[illegible] diameter, with only one outlet), an[illegible] barrels are also too small. The hyd[illegible] spaced too far apart.

The Fire Department, as a whol[illegible] a fairly efficient force, its chief weakn[illegible] the extensive territory to be covered by t[illegible] ber of companies in service, and the com[illegible] number of men assigned the many comp[illegible] central parts of the city. The appropriati[illegible] Department have for many years been [illegible] averaging recently less than $1 per capit[illegible] than one-half the amount devoted to th[illegible] in some other conservative cities.

The new building laws, although [illegible] improvement on the old ones, are deficient i[illegible] eral vital points, including some features of [illegible] tection at elevators, the allowance of mill and [illegible] -burning construction in excessively high b[illegible] ings, and lack of provision for enforcement o[illegible] law for protection of exposed openings on [illegible] buildings. The already extensive fire limits should be enlarged to include the Union Stock Y[illegible] system. The efforts being made by the present Building Commissioner to enforce the buildin[illegible] laws are commended. Electricity matters are handled in an up-to-date and approved manner by both the city and the Underwriters' Association."

Among the numerous final recommendations of the Committee, the following may be mentioned: The installation of the separate fire main system for the congested value district and adjacent territory, substantially as laid out by the High Pressure Commission. On this system no mains should be less than 12 ins. in diameter, hydrant branches and barrels should be not less than 8 ins. in diameter, each hydrant should preferably have four outlets, each with an independent valve; at least two hydrants should be set at each street intersection, and in no case should hydrants be spaced more than 200 ft. apart. The pumps for this separate service should discharge at their rated capacity against the 250-lb. head and be capable of operating under a head of 300 lbs. A constant pressure of 150 lbs. should be maintained in the special fire system. The pressures in the general distributing system of the city should be so increased as to give a minimum of not less than 50 lbs. during the period of maximum domestic consumption.

Immediate steps should be taken to establish a general meter system or a rigid house-to-house inspection service, or both. For the purpose of water waste investigations the city should be divided into permanent districts and the flow into each measured. Street mains should be relaid where large leakages are shown.

The reinforcement of distribution system is recommended, to include mains advised by the city engineer in May, 1905, and also a number of additional mains, the latter from 36 to 12 ins. in diameter. The same general recommendations are made as to sizes of mains supplying fire hydrants, and size and character of hydrants, as have already been noted under New York.

DETROIT, MICH.

The average per capita water consumption during the past five years has ranged from 160 to 183 gals., having been 173 gals. in 1905. Only large consumers are metered, and only about 100 meters per year have been added for the last five years.

There are no recording pressure gages on the system, but at 33 points, mostly fire department houses, ordinary gages, read at hourly intervals, are maintained. Of 174 hydrants tested (out of a total of 4,021), 62% gave a free discharge of 600 gals. or more per minute. These tests, as in the case of tests in the other cities, were made in groups of six.

The committee considers that the per capita water consumption "is unreasonably large" and has already "encroached dangerously on the limited margin provided for fire protection in the small street mains which are characteristic of the distribution system." Immediate measures

should therefore be taken to stop all available waste. Pressures are too low throughout the city, and although they may be "somewhat increased by a substantial reduction in consumption," yet the normal static pressure now maintained at the pumping station is too low for satisfactory protection.

As to the final recommendations are the following:

That the whole city be supplied in a single service under pressures at the pumping station sufficient to maintain a minimum, during maximum domestic consumption, of not less than 75 lbs. in the congested value district; that an additional pump of about 25,000,000 gals. capacity be installed; that the distribution system be locally reinforced by the installation of [a considerable number of] 24 to 12-in. mains.

The same general recommendations regarding mains supplying fire hydrants and size of fire hydrants as were noted under New York are included in the Detroit report. It is recommended that all gate valves be inspected at least twice a year, put in good order, and records of the inspections kept. A building of fire protection construction is recommended for fire alarm headquarters.

Under the head "Building Department" a number of important recommendations are made, beginning with one for the creation of such a department and followed by another for a thorough revision of the building laws of the city. It is recommended also that enough inspectors be employed to secure the proper enforcing of the laws; that all records be systematically filed; that fire escape ordinances be rigidly and impartially enforced; and that the fire limits be revised.

A code of regulations relating to explosives and inflammables is recommended, and also a force of inspectors to look after this matter. Under "Electricity" the enforcement of ordinances, reinspections of wires, placing wires underground, separation of low and high tension wires, and the continuation of electrolysis tests, are recommended. Finally, it may be noted that automatic sprinkler equipments are recommended "in all buildings which, by reason of their size, construction or occupancy, singly or combined, might act as conflagration breeders."

STEEL TRACKS FOR HIGHWAYS.

Numerous propositions and designs for steel tracks or wheelways on common roads have been made from time to time, and a few of these have been put in actual experimental service. Some of these have been described in our columns.* but it has been shown that the tractive effort required for wagons on a steel track covered with dirt and dust is not very different from that on a good road surface, while the cost would in most cases be out of proportion to the benefits obtained. Two recent designs of steel track for highways are shown herewith, and one of these has been built at two places. The design shown in Fig. 1 is a system patented by Mr. T. H. Gibbon, and consists of a rail of T section, having the vertical web carried in grooves in cast-iron chairs or supports, spaced 8 ft. apart longitudinally and connected transversely by tie-bars. The rail has a width of 6½ ins., and on the inner edge is a ¼-in. rib to guide wheels and keep them on the track; but as the result of experience it has been recommended that this should be at least ¾-in. high. The rail may also be reinforced by a rib on the under side of each edge. This track has been built at Etna, Pa., for a distance of about a mile on the Allegheny and Butler road. At the Etna end there is 500 ft. of double track. The design shown in Fig. 2 has the same form of rail, but the cast-iron substructure is dispensed with. It will be seen that the web of the rail is embedded in a concrete beam, to which it is anchored at intervals by hooked bars. This is designed to be used in connection with a concrete foundation for the road. A double track line on this system was to have been built for about a mile at Louisville, Ky., but as the county authorities desired to disturb the macadam paving as little as possible, the design shown in Fig. 1 was substituted, but with the tie-bars omitted. Trenches were dug just wide enough to admit the cast iron substructure, and when this had been properly set to alinement and grade the trench was filled with Portland cement concrete. In view of the weight and cost of the cast iron supports, it would seem that the design shown in Fig. 2 might well have been adopted in this case, the rail being supported temporarily by blocking, as is done in laying street railway track on concrete beams. The two tracks are 5 ft. apart between the edges of the rails.

The cost of the track as shown in Fig. 2 is given as about $9,000 per mile, including concrete. The cost of track with cast iron supports is not given, but would, of course, be very much higher. The tracks at Etna and Louisville are on main thoroughfares, on which the traffic is heavy, and it is expected to build a mile of road this season for the county commissioners of Allegheny County, Pa. Both of the designs above described are being introduced by the Steel Highway Track Construction Co., 420 Bakewell Building, Pittsburg, Pa., and for drawings and information we are indebted to Mr. William Martin, Engineer for the company.

*Descriptions and discussions of "Steel Tracks for Highways" have been published in Engineering News:

1899: I., 228	1902: I., 182, 365, 459, 504
1894: I., 30	1902: II., 477
1896: I., 304, 353	1903: II., 546
1897: II., 154, 280	1904: II., 445
1899: II., 367	1905: II., 197
1901: II., 81	

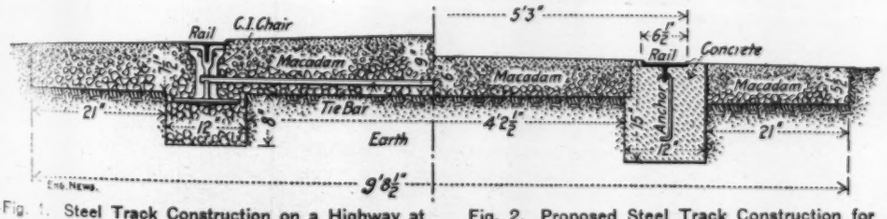

Fig. 1. Steel Track Construction on a Highway at Etna, Pa.

Fig. 2. Proposed Steel Track Construction for Highways.

A NEW TYPE OF SLAG CAR.

A new and interesting type of slag car has lately been placed on the market. The ten-ton car illustrated is 15 ft. long, 6½ ft. high and weighs 27,000 lbs. empty or 47,000 lbs. when filled with slag.

The bowl is made in five sections, the bottom being one piece with four quarters forming the sides, thus allowing worn or broken parts to be easily removed and new ones substituted. These sections are securely bolted together and tied to a steel supporting ring (a) with key bolts, the ring being riveted to pinion-toothed trunnions (e), which roll on a track in which a rack is cut. The pinion and rack are both made open between the teeth to prevent their being clogged by any slag that might be spilled on them. The trunnions (e) are rolled by means of a sleeve (h) which is operated through a lever (d) by a 12-in. compressed air cylinder (g), which operates on 60 lbs. air pressure and tilts and holds the pot in any desired position. A hand wheel and screw (f) is also provided for dumping the bowl by hand should the air supply from any cause fail. The bowl in dumping is carried to the side of the car by the rolling of the trunnions, thus dumping outside of the rails, while an apron (k) in the middle of the truck prevents any drippings from falling on the track. Moreover, the side of the bowl makes an angle of 30° with the vertical, when the bowl is tilted to its extreme position, which allows the slag skull to readily slide out.

A NEW TYPE OF SLAG CAR.
Power and Mining Machinery Co., Cudahy, Wis., Makers.

The entire body of the car is carried on eight springs (c) placed under the front and rear supporting frames, these frames being tied together by two 100-lb. rails (b), these rails being extended to carry the Tower automatic couplers, which are provided with the usual hand rod at the side of the car for uncoupling. The springs rest on the main bearing boxes, which are fitted with phosphor bronze bearings and are kept lubricated by removable oil waste boxes. One of each pair of wheels is also provided with a bronze bushing so that it can revolve on the axle when going around a curve.

These cars, while being made as simple as possible, have been constructed with special reference to the rough usage to which they will be subjected and a large factor of safety has been used in their design. They are made in various sizes up to 15-ton capacity, with or without the air cylinder for tilting, by the Power and Mining Machinery Co., of Cudahy, Wis.

SUBMARINE SWEEPS FOR LOCATING OBSTRUCTIONS IN NAVIGABLE WATERS.

By Francis C. Shenehon,* M. Am. Soc. C. E.

In the best modern practice a piece of submarine excavation for a ship channel or harbor, before acceptance from the contractors, is not only sounded as evidence of proper depths having been attained, but in addition is examined by a sweep to make certain that no isolated points, boulders or fragments, project above the grade plane. The sweep rarely fails to show up masses still needing removal.

In its best known form a sweep is a bar of iron, or several of them, suspended from a raft or scow, at a fixed depth below the water surface. This is moved over the area under examination so that the bars pass over every foot of it; some tell-tale device indicating the contact of the bars with any bottom obstacle.

In 1879 a sweep 130 ft. long, with bars of flat rolled iron suspended by chains from a raft of timber, and raised and lowered by windlasses, was built on St. Mary's River, under the supervision of Mr. Alfred Noble, Past Pres. Am. Soc. C. E. This has been used consecutively since that time in the extensive channelization of that river. On this the writer served his apprenticeship in sweeping.

It is clear that an efficient sweep, efficiently used, makes absolutely certain the complete absence of submarine obstructions; and it is equally clear that the information given by the sounding pole or weight is presumptive, only, on this vital point. The sweep is therefore a necessary instrument in dealing with submarine excavation.

The bottom of a dredged channel is likely to be more ragged than the bottom of a natural waterway, but despite the leveling tendencies of natural forces, reefs and shoals do reach up unexpectedly from deep submerged plains, and glacial regions are strewn with boulders.

It follows that river, lake and ocean areas of moderate depths cannot be certified clear of dangers to navigation unless swept; and advanced hydrographers have been seeking practicable methods of sweeping.

The problem of sweeping dredged channels is simple because the areas involved are small; ten miles of ship channel means a square mile only of bottom, and may be ten years in the making. The length and speed of the sweep is of minor importance. But a single belt of Lake Erie requiring sweeping may be twenty miles long and five miles wide, and a bay of the ocean may have fifty square miles of area, and each need to be done in the good weather days of a field season. These are the large problems facing the two great hydrographic organizations of the country, the Lake Survey, which makes the navigators' charts of the Great Lakes, and the Coast and Geodetic Survey, dealing with our salt water areas. Each has its fleet engaged in surveys of the unseen lands under lake and ocean, in the interests of safer navigation.

In 1893-5 Capt. Smith S. Leach (now Colonel), of the Corps of Engineers, built, under a Lake Survey appropriation, a hydrographic sweep to examine the irregular bottom of the St. Lawrence River in the Thousand Island region. It was 350 ft. long, of 2½-in. gas pipe, made continuous by ball-and-socket joints, and suspended by wire cables from a narrow cedar raft. In length it was a distinct advance on prior sweeps, and the later sweeps of the Lake Survey are debtors to it for some details. It, however, moved slowly, and the problem of adequate capacity for large hydrographic surveys still remained.

A sweep adequate to cover large areas must have either great length with moderate speed, or moderate length with high speed. The best types of each have been developed and used by the Lake Survey in the past four years. The minimizing of the water resistances of the submarine member have been essential for the speed sweep and the long sweep.

The Lake Survey Steel Pontoon Speed Sweep is 280 ft. long, and is made up of seven 40-ft. sections, coupled together. Five sections, making a 200-ft. sweep, are shown in Fig. 1. The Pontoon Sweep was built when the Lake Survey was in charge of Major W. L. Fisk (now Colonel), Corps of Engineers, U. S. A., and was designed by Mr. E. E. Haskell, Principal Civilian Engineer, aided by various members of the Survey. The sweep may be of any length which is a multiple of 40 ft., up to its full 280 ft. The cylindrical steel hulls are well adapted to easy and swift passage through the water. The steel trusses stiffen the superstructure in a seaway.

*U. S. Lake Survey, Detroit, Mich.

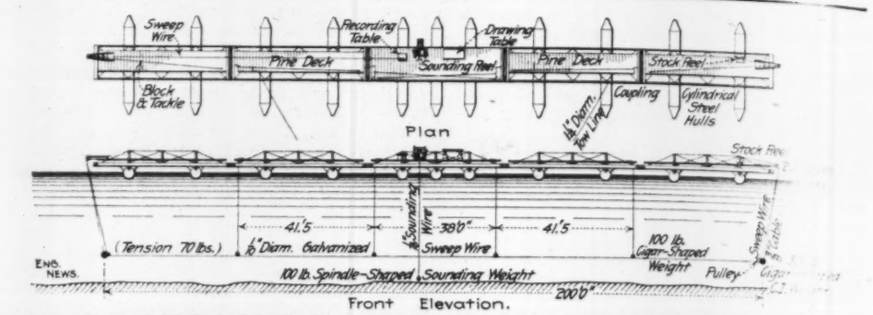

FIG. 1. FIVE SECTIONS OF STEEL PONTOON SPEED SWEEP, DESIGNED BY E. E. HASKELL, M. AM. SOC. C. E.

As originally designed the sweeping member consisted of iron bars 2⅞ ins. in diameter, suspended by ¼-in. steel cables, two 19½-ft. bars to each 40-ft. pontoon section, with an aggregate weight of 5,900 lbs. for the full sweep length. (See Fig. 3.) By an ingenious arrangement of cables all bars were lowered or raised simultaneously by four windlasses. Some excellent work was done with the bar sweep.

A radical objection to the bars, however, existed in the very considerable resistance the full system presented to towing through the water, which made difficult such high speed sweeping as the hulls are well adapted to. The main reason for the heavy sweep bars was to make them hang as nearly plumb as may be when under way. When they swing astern, under the water resistance, they lift out of the grade plane. If heavier cylindrical bars still be used the degree of back slant is lessened, but the towing resistance increases. A lessening of the slant, and a lessening at the same time of the towing resistance, can be effected, by using lighter round bars, with cigar-shaped cast-iron weights at the points of cable support. These castings passing nose-on through the water meet very little resistance, but give the effective weight needed to reduce the slant of the cables.

The angle of back slant depends on the ratio of the water resistances to the submerged weight of the sweeping member. Letting s represent this angle, as measured at the water surface, R the sum of the resistances, and W the total weight,

$$\text{Tangent } s = \frac{R}{W}.$$

If R be reduced, W can be correspondingly lightened. The logical limit of this elimination of weight and resistance is reached in the use of light wire for the horizontal member. Instead of cumbersome bars, with the weights necessary to keep the angle s within proper bounds, spaced along the wire. The use of wire and projectile-shaped supporting weights is the principal contribution made by the writer to the design of the Lake Survey Pontoon Speed Sweep.

In preparing the pontoons for work in Lake Erie, in the spring of 1905, some changes were made in the hull connections and in the coupling device, and five sections were equipped with a sweep of galvanized wire 0.1-in. in diameter, replacing the 2⅞-in. bars. In Fig. 1 the method of supporting the wire and of putting it in tension is shown. The wire is continuous from the stock reel, over an over-hang sheave, down to the 300-lb. terminal weight; then 200 ft. of horizontal sweep wire in 40-ft. spans is threaded through the intermediate 100-lb. weights, up to the deck again, and fastened to the hook of a 200-lb. spring balance. A normal tension of 50 to 70 lbs. was applied by straining up on the stock reel. At the sweep ends the tension tends to swing the terminal weights towards each other, and for this reason they are made much heavier than the intermediates. The vertical sag in the 40-ft. wire span is less than ½-in. The total submerged weight was 1,000 lbs., and the total resistance of the sweep member was about 300 lbs. at five miles an hour. The angle of back slant at this speed was 30° for the middle cables.

In the months of August and September the Pontoon Speed Sweep, operated by the steamer "General Williams," swept to a depth of 25 ft. 17 square miles of exposed areas in Lake Erie. Soundings were made at the same time.

The survey of the block 2½ miles long and nearly 2 miles wide outside of Ashtabula Harbor is representative of the method of work. An alined base of four spar buoy sextant signals flying flags was first set out by the steamer, and read in by triangulation. These were at the north or off-shore edge of the block, and extended east and west across its 2½ miles of width. In addition, shore and harbor points were read in for sextant signals. A field sheet was projected, scale 1 to 5,000, with all signals platted on it. With these preliminaries completed, a start was made on the south side of the

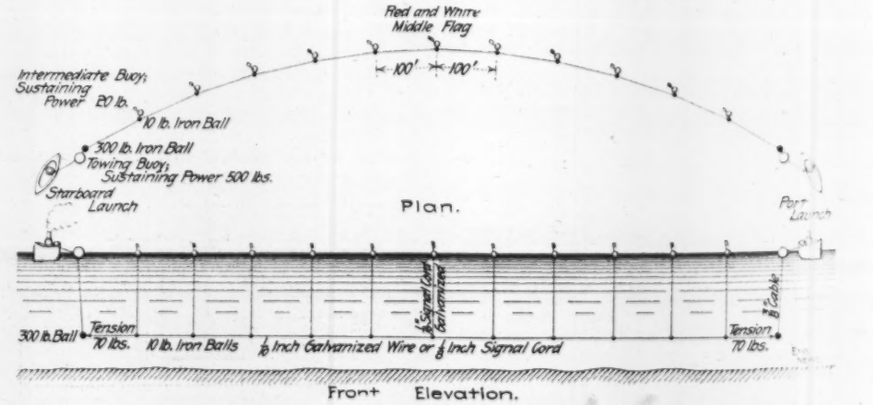

FIG. 2. A 1,200-FT. LENGTH OF LONG-WIRE SWEEP, DESIGNED BY F. C. SHENEHON, M. AM. SOC. C. E.

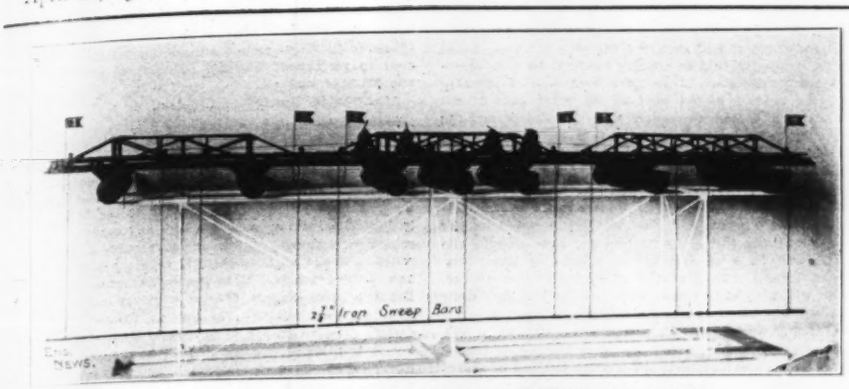

FIG. 3. MODEL OF THREE-SECTION PONTOON BAR SWEEP.

signal line, and a belt 200 ft. wide was swept westward, the north end of the pontoon just clearing the signal flags. Every two minutes the position of the center of the sweep was read in by sextants, and its locus immediately platted by a draftsman working on the pontoon.

Half-minute soundings were taken with a reel on the center section. At the beginning of the belt a red-flagged marker buoy was dropped fair with the south end of the pontoon, and additional red markers were dropped every five minutes, as guides for the return belt. In sweeping belt No. 2 the red markers were picked up with a lap of 20 ft. on the first belt, and black markers dropped from the other end; on the third belt white markers were used, and on the fourth red markers again renewed the cycle. The angle of back slant was read on every belt, and the sweep lowered to compensate the rise due to this. The speed ranged from four to five miles an hour.

The spring balance showing the wire tension rested on the recorder's table and gave unmistakable indication of the presence of any obstacle. The elevation of the lake surface was taken from the automatic gage records and used as a datum for sounding and sweeping depths. The weather permitted sweeping two to three days each week.

For continuous line sweeping the best day's record was a mile and a half, and for three consecutive days this was attained. The full-length sweep of seven sections has a capacity of two square miles a day under favorable conditions.

The capacity of the pontoon sweep depends on the predominance of the factor of speed in the product of speed and length, which gives the area covered, and speed demands a craft of structural importance. Not every organization, however, can have an expensive speed sweep, and a great organization like the Lake Survey cannot very well have one for each of its hydrographic parties; yet any hydrographic party without a sweep is lame.

In 1902 the writer was in immediate charge of the resurvey of the St. Lawrence River. He needed a sweep, but had none. An 8-ft. shoal was shown on the navigators' charts close to the channel, just below Alexandria Bay, and for 30 years vessel masters had carefully avoided that spot. The sounding patrol of the resurvey showed nearly 80 ft. there. This was in a region where rocks rose up almost like obelisks from 200 ft. of water, and it would not do to erase the printed shoal from the chart except upon positive assurance of its absence. Not finding it by sounding, made its absence presumptive only. For this reason the writer designed and built a sweep 330 ft. long and swept the area, all in one day. This was the origin of the long wire sweep.

It is briefly described and illustrated, page 2764 of the Report of the Chief of Engineers, United States Army, for 1903. It embodied the same principles as the 1,200-ft. (see Fig. 2) and 2,000-ft. sweeps built and used by the writer in 1903 and the 3,000-ft. sweep of May, 1905. The 1,000-ft. sweep operated by the U. S. Coast & Geodetic Survey during the past season in sweeping 43 square miles in Frenchman's Bay, on the Maine Coast, was modeled after the St. Lawrence River sweep of 1902.*

The long wire sweep consists of a series of 100-ft. sections of 0.1-in. galvanized iron wire, or ⅛-in. galvanized signal cord, linked together with light iron rings or swivels, stretched taut at a fixed depth, as 25 ft., below the water surface. At each link is a detachable 10-lb. cast-iron ball, and from each ball a suspending wire reaches up to a spherical buoy. The buoy holds the sweep wire up; the iron ball holds it down when moving. The 100-ft. span of wire between the links is kept practically without sag by being drawn taut under a tension of upwards of 70 lbs. At the sweep ends the wire is fastened to 300-lb. cast-iron balls. From these heavy balls ⅝-in. cables lead up to large towing buoys.

In operation, two launches, one attached to each towing buoy, move the sweep over an assigned course. The launches head on courses diverging from each other, and from the line of travel, at an angle which keeps the sweep taut and at the same time advances it along the course.

The intervention of the large terminal buoys and weights transmits the surface horizontal pull of the launch down to a horizontal pull on the sweep wire. The couple at each sweep end, formed by the opposing horizontal pulls of the tow line and the sweep wire, is balanced by the couple formed by the gravity force of the heavy weight and the flotation of the large buoy. If the pull of the launch shows 70 lbs. on a spring balance when sweeping to a depth of 25 ft., a 300-lb. (submerged) weight will swing $70 \times 25 \div 300$, or 5.8 ft., off the vertical. The intermediate small buoys, on account of the water resistance, lag a little behind the 10-lb. balls, and a similar couple is formed. Both end cables and float wires are lengthened to off-set the lift due to the inclination.

As the sweep moves at a uniform speed through deep unobstructed still water, it takes a curve in the horizontal plane similar to the curve in a vertical plane of a suspended cable. This is due to the water resistances applied along every foot of the sweep wire and to additional concentrated loads at each 100-ft. link, caused by the greater resistances at these points. It is evident that the back-sag of the sweep for a given speed will be reduced to a minimum by skillful design in the details, eliminating all needless resistance, and that for a maximum allowable back-sag a well-designed sweep will give higher speed, and therefore greater capacity.

A sweep 1,200 ft. long for two-launch use will cover a belt over 1,000 ft. wide at a speed of upwards of a mile an hour and has a capacity in unobstructed areas of two square miles in a working day. The cost of such an instrument need not exceed $100, with the best of construction, and it may be built for half that sum. Each vessel of a hydrographic fleet may therefore be equipped with a serviceable sweep without handicap of cost, deck space or care.

Preparatory to operation a base of red-flagged marker buoys is set out in good alinement over, say, a length of two miles on the north margin of the block to be examined. These trace the path to be traveled by the north or port launch moving eastward, and are picked up in turn by an attendant small boat just in advance of the sweep. Simultaneously the south or starboard launch drops black markers as guides for the return traverse on belt No. 2. At the east end of belt No. 1 the south launch tows the sweep end-on due south into position for belt No. 2. The second belt laps 100 ft. on the first to cut out the possibility of not fully covering the area.

During the progress of the work the north launch controls maneuvers, takes all soundings, and does all instrumental work. Soundings are made every two minutes and sextant reading every five minutes. In this way the area swept is also gridironed by lines of soundings 1,000 ft. apart, with soundings every 200 ft. along the lines. The position of the south launch is taken from the north launch by reading the angles, sextant-signal-to-south-launch and south-launch-to-middle-buoy-of-sweep. The first angle gives its direction from the north launch, the second its distance, because the chord length of the sweep is a function of the angle. The launches keep the sweep chord normal to the path traveled and make it of fixed length by keeping the angle between chord and middle buoy constant, as at 20°.

When an obstruction is met by the sweep wire the fair curve traced by the intermediate buoys is destroyed. If the wire slips up on a rounding rock or flat sand shoal, the buoys near it topple over. The shoal spot is then buoyed out for detailed examination, the sweep wire is lifted over it, and the work proceeds.

The long wire sweep does not exclude navigation in the path in which it is operating. Vessels may pass through it over the sweep wire in the 100-ft. space between any two buoys. The only horizontal member is the sweep wire well below the keels of the passing boats. This is a distinct advantage in channels of limited widths.

At night the sweep is drawn taut out of the traveled way, and each end anchored with a small kedge. When the work is done it is

*[Described and illustrated in Report Supt. U. S. C. & G. Survey, 1904-5, in an article by D. B. Wainwright, Assistant.—Ed.]

FIG. 4. THREE-SECTION PONTOON SWEEP IN OPERATION.

reeled in on shipboard, with buoys and weights detached.

In locating the wreck of the steamer "Specular" in Lake Erie last May the writer used a 3,000-ft. sweep. One end was pivoted on an anchor, while a launch swung the free end around it. The circle swept was a mile in diameter. The wreck was found in the first circuit.

THE DESIGN OF SWING BRIDGES, FROM A MAINTENANCE STANDPOINT.*

By C. H. Cartlidge.†

In looking over a number of plans for swing bridges by different engineers, the writer has been struck by the absence of provision for certain functions, relatively unimportant, yet affecting both the ease and cost of maintenance. A study of various plans is a profitable preliminary to any designing, as it is often to be found that existing conditions have been satisfactorily met. By going over them all, eliminating such details as seem unsuitable, and selecting the good ones, it is possible to make of the composite, a really good design. A choice, however, must often be made between two or more apparently equally good details, and this is true in the case of the sort of center to be employed.

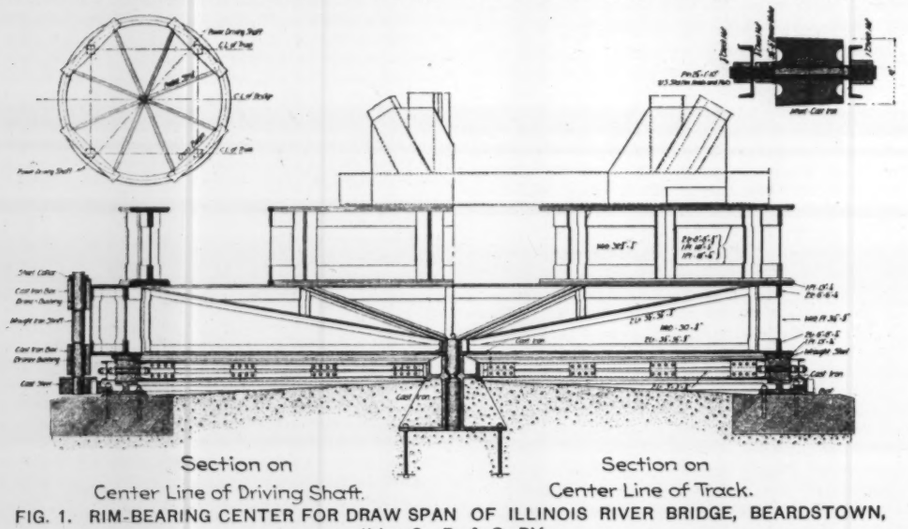

FIG. 1. RIM-BEARING CENTER FOR DRAW SPAN OF ILLINOIS RIVER BRIDGE, BEARDSTOWN, ILL.; C., B. & Q. RY.

In swing spans, the choice of the type of bearing to be used lies between three, each of which has its advocates. These may be classified as follows: 1, Center bearing; 2, Rim bearing; 3, Combined center and rim bearing.

A center-bearing turntable, in which all loads are carried to the pivot, was at one time the most popular. As in this case there is no drum, with its complicated stresses and doubtful distribution of the loads on the wheels, the comparative certainty of the mathematical work appealed to designers. Some provision has to be made, however, against tipping the span while being turned, and trucks running on a circular track must be connected to the drums by girders of considerable strength, so that the theoretical simplicity is not realized. One great advantage which accrues to a center bearing is that of ease of turning, and while everything is new and in adjustment this advantage is realized. Should there be any excessive wear, however, this is soon lost, and it is necessary to make bearing areas as large as practicable, in order to prevent such wear.

The complications referred to above, involved by the use of a rim-bearing center, are more theoretical than actual, as experience with spans of widely varying length has demonstrated. The drum should of course be deep enough to avoid deflection, and if there is head room to permit this, a rim bearing will be found extremely satisfactory, especially if the span is of moderate length. For spans up to 300 ft. the writer usually employs this style of center, and one such is shown in Fig. 1. This is the rim bearing center for the draw span of the Illinois River bridge, at Beardstown, Ill.

You will note the depth to which the pivot castings are sunk in the concrete piers. This is an important detail, and obviates a good deal of trouble from loosened anchor bolts and consequent loosening of the pivot. Much difficulty of this sort has been encountered in the past. A rigid pivot, such as this anchorage provides, permits much less chattering and vibration when the bridge is turning than one which will allow of any play whatever.

Most old draw spans were designed with adjustable radial rods, one end of each rod carrying a wheel. These rods were usually held to spacing by light bars or sometimes light channels. There have been several cases in which the binding of the nuts on the outer ends of the rods has caused them to revolve with the wheels, and the other ends being held, the rods were badly twisted, some even being twisted in two. This trouble is entirely obviated by the use of a stiff ring of channels held to gage by batten plates between the wheels, and having stiff radial arms to the pivot. The wheels run on axles, adjustable radially, with tool steel washers to avoid danger of the nuts being turned by friction and thus altering the adjustment. In later designs these washers have been made of bronze, with a greater reduction of this danger.

The writer's experience with center-bearing draw spans has been such as to prejudice him against them for spans of any magnitude. It seems to be difficult at any reasonable cost to proportion the pivot bearing so that it will not wear, and any wear on a pivot bearing is expensive to repair. On one draw the wearing away of the bronze bearing in the pivot allowed the upper and lower castings to rub, making the turning of the draw a very noisy operation, while the few wheels provided to steady the span while turning were overloaded and cut the circular track badly.

A design which, for ease of operation and repair and low maintenance cost has proved to be quite satisfactory, is shown in the next drawing, Fig. 2. This is the center for the single track draw span over the St. Croix River, near Prescott, Wis. The span is 368 ft. and is designed to carry a uniform train load of 7,000 lbs. per ft., so that it is quite heavy. The beams bearing on the center casting are designed to carry half the dead load to the casting. The adjustment of the load is by means of shim plates between the beams and the top of the pivot. The adjustment is made during erection, the beams first being allowed to rest on the rollers with the center casting clear. The center is then jacked up until the drum just clears the wheels. After noting the amount of shims to half its amount are put in and the be... ered to permanent bearing. This is of course ... approximate method.

Attention is directed to the depth to which th... bearing is sunk into the masonry in this design ...

A number of spans have been built with center ... of cone-shaped rollers. The writer has had to ... some of these, though at this writing all have ... placed. The experience gained in the maintenance of these conical roller centers has led to the design in Fig. 2, involving lenses of steel and bronze. ... rollers were found to wear unevenly, some of the ... rolled, but slid on the bearings, although they ... and cleaned yearly. It is hardly necessary to ... the expensive nature of the work of taking ... cleaning these rollers. The bearing adopted has ... defect. The resistance to turning is theoretically ... but it is a simple matter to provide the necessary additional horse-power in the engine, and at a cost ... for capital and interest than the cost of maintenance of the cone-roller bearings, to say nothing of the freedom from trouble.

An oil hole is drilled through the saddle casting and the two upper lenses; a pipe running to the bridge floor is tapped into this and is capped with an oil cup, so that the bearing is constantly lubricated. As the parts of the bearing are made to a close working fit no dust can enter. These provisions for lubrication and for protection against dust are quite as important to the maintenance department as any structural provisions, and they are points most frequently overlooked. In this connection the three oil holes in the hubs of the rim-wheels are worth mention, as it is possible for the oiler to lubricate the axle no matter what the position of the wheel. As it is generally very much easier not to oil these wheels, than to do so, it is just as well to make the process as easy as possible.

The next drawing, Fig. 3, shows the details of the end lifting device for the St. Croix bridge. This is typical of practically all such devices in use on the C., B. & Q. Ry., but it differs in some few details from the first ones built of similar design.

The necessity for an efficient end lifting apparatus is apparent to every designer, and the writer's experience with wedges has led him to the conclusion that the difficulties in the way of getting adequate lift with them are too great. It is very likely that if the power of the engines had been greater there would have been no great difficulty, but it was found in practice that when the pedestals were set at an elevation required to give the desired lift the wedges could not be driven. When they were adjusted to such a height as to allow of the wedges being driven, there was no reaction with a heavy train on the opposite arm of the span. The end lift in Fig. 3 has not failed to provide all required uplift and as its construction is such that its maximum efficiency of thrust is reached at the time of maximum load it is very easily handled. It is, of course, not in the least degree novel, but there are some features which are, so far as the writer is aware.

In the earlier forms of end-lifts the nut traveling on the horizontal screw was of steel, unbushed. At times of heavy duty, when a warm day caused the draw to deflect, this nut would sometimes become welded to the screw. Bushing with phosphor bronze has stopped this entirely. The vertical links which are under the chord end are beveled on the lower end to engage a similarly beveled surface on the casting. When they are in position they form a positive lock for the span and serve to bring it to

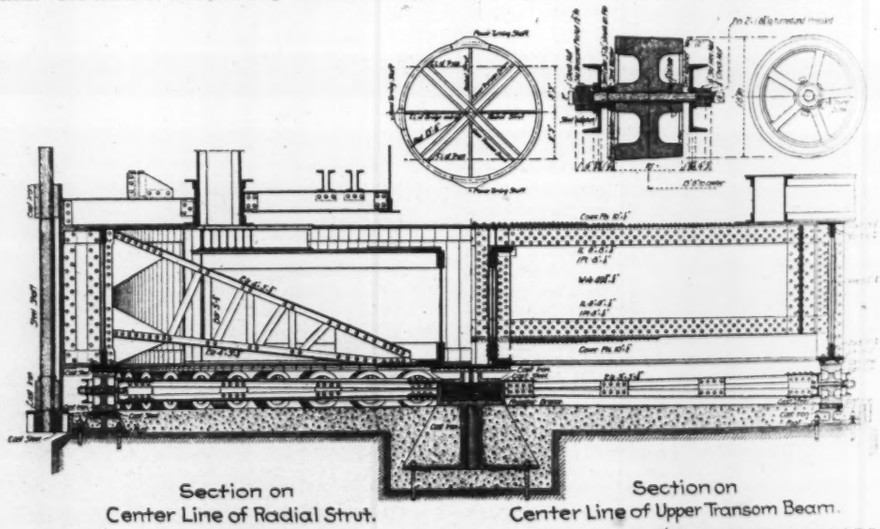

FIG. 2. CENTER FOR SINGLE-TRACK DRAW SPAN OVER ST. CROIX RIVER NEAR PRESCOTT, WIS.; C., B. & Q. RY.

*Abstract of a paper read before the Western Society of Engineers, Chicago, April 18.

†Bridge Engineer, Chicago, Burlington & Quincy Ry., Chicago.

ex[illegible]—a very difficult thing to do by means of the tur[illegible] gear alone. The upper surfaces of these links bea[illegible] against the steel casting which is riveted to the low[illegible] chord. As the upper pinholes in the links are ma[illegible] considerably larger than the pin the latter is not ca[illegible] upon to take any load while the lift is in action. Th[illegible] nection of the two base castings by plates and ar[illegible] is very necessary as it relieves the anchor bolts of the horizontal components of the lifting thrust.

The rail-lift illustrated was, the writer believes, first [illegible]ed by the late Geo. S. Morison. The lifting rod is [illegible]d the lower half free to follow the lever down as the [illegible]an is lifted, until the operation is nearly complete, when a projection on the lower rod trips the trigger [illegible] the upper half, with the result that the rails fall with a jar sufficient to drive them into place without further adjustment. The action of the combined apparatus in first centering the ends, then lifting them and

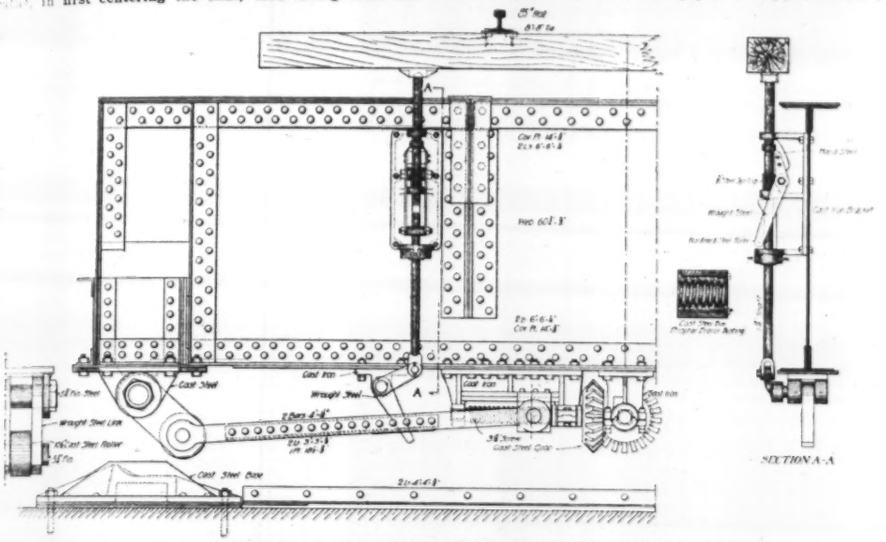

FIG. 3. DETAILS OF END LIFT FOR ST. CROIX RIVER DRAW SPAN.

finally dropping the rails, is found to work admirably. While the rail-lift looks somewhat complicated there has been no difficulty with any which we have in use.

There are certain details of design of the structural part of draw-spans which affect the question of maintenance to a considerable extent, and of which little or no mention is made in text-books. It may be laid down as a general rule, that there should be absolutely no adjustable members in the trusses. All parts subject to complete reversal of stress, should be stiff members and have, as far as possible, riveted connections. No pin connections should be employed save for eye-bar members. This is particularly true of the connection between the end of the lower chord and the foot of the end post. The constant reversal of stress at this point, due to lifting and lowering the ends of the draw, very soon develops serious wear on pins and pin holes. With a properly designed riveted connection, no play being possible, there will be no difficulty.

In draw-span design, perhaps to a greater degree than in any other, simplicity and rigidity are the prime requisites to economical operation and maintenance.

DESIGNING THE 18-FT. STEEL PIPE OF THE ONTARIO POWER COMPANY, NIAGARA FALLS.

By Joseph Mayer,* M. Am. Soc. C. E.

The writer was requested by the owners to make as consulting engineer a design for a pipe 6,000 ft. long, able to supply water of 60,000 HP., with a fall of 175 ft., used by turbines of 70% minimum efficiency. The pipe was to be buried at least 3 ft. deep below the surface. The survey gave an average surface slope of 0.00425. It was convenient to use a hydraulic slope of 0.004. The maximum depth of cover was about 10 ft. The material to be excavated was for some distance wet clay to a considerable depth, but mostly gravel and sand. In some places rock excavation 7 ft. deep was required. The volume of water per second is evidently

$$\frac{60{,}000 \times 550}{175 \times 62.5 \times 0.70} = 4{,}310 \text{ cu. ft.}$$

For a smooth pipe the use of Kutter's formula with coefficients of roughness of 0.011 and 0.013 gives velocities of 22.03 and 18.68 ft. and capacities of 5,000 and 4,240 cu. ft. per sec. for 17 ft. diameter.

Such velocities as well as the diameter are far beyond the limits of the available tests confirming the correctness of Kutter's formula. If the pipe could be relied upon to remain smooth a diameter of 17 ft. would allow a sufficient margin for inaccuracy of the formula. It was, however, decided to use lap joints for the circular and longitudinal joints of the steel pipe finally adopted. The pipe is therefore not entirely smooth when new and sediment may be deposited, starting at the joints, in spite of the high velocity. Rust, producing roughness, is also a possibility. A diameter of 18 ft. was chosen. On account of the absence of tests for pipes of approximately the same dimensions with similar velocities the writer was unable to convince the other engineers of the correctness of his opinion that a 17-ft. diameter pipe with butt joints circumferentially and with all rivets countersunk inside was the best to adopt. Investigation of past experience soon convinced the writer that there is no paint which will certainly protect a water pipe from rust for more than a few years. There are extreme variations in the durability of pipes and other iron and steel submerged in water. They are caused mainly by the quality of the water. This question of the probable durability and degree of smoothness of the pipe was considered of the utmost importance by the writer. He therefore collected as many facts in regard to it as his limited time allowed. These facts are generally important. I therefore quote portions of my report on the subject.

PROTECTION FROM RUST AND THE PROBABLE LIFE OF RIVETED STEEL PIPE.

The paints used for protection from rust of steel bridges and steel frames of buildings consist of lineed oil and a neutral pigment. It is universally conceded by competent judges that this paint is practically worthless for water pipes. Refined tar mixed with some lime and linseed oil applied hot has been extensively used for them in the past and is even now recommended by some experts. It has, however, proved unsatisfactory. Lately refined asphalt and various mixtures of refined asphalt and refined tar have been used, but no paint or asphalt coat has prevented rusting and the formation of tubercles on the inside of the pipes. . . . . Alkaline soil prevents rust. Cement is alkaline and has proved an excellent preventive of rust. Since the coats of asphalt often last only for a limited time the pipe is unprotected in spots during most of its life. . . . .

According to Naval Constructor (now Rear-Admiral) Francis T. Bowles, U. S. Navy, good unpainted iron or steel plates will lose on one surface in 100 years 0.30 to 0.50-in. in thickness if immersed in sea water, 0.02 to 0.03-in. in pure fresh water and from 0.25 to 0.3-in. if exposed to the atmosphere. This would easily lead to the belief that the pipes will not suffer much from rust on the inside if they always run full. The inference may, however, be entirely erroneous. It makes a large difference whether a plate is only immersed or exposed to rapid flow of water over it. When a riveted water pipe ¼-in. thick in Rochester, N. Y., was inspected after 26 years' use only a few plates out of 14,000 needed repairs. Since this is important I went to Mr. Emil Kuichling, the former City Engineer of Rochester, to obtain the details. The pipe was covered with a coat of asphalt and tar; the coat was carefully inspected. The pipe had defective expansion joints (at present no expansion joints are used). It leaked at these joints and was therefore dug out in many places. In a few places it was found that it had rusted through in spots from the outside. These places occurred where the pipe was embedded in red clay. It nowhere rusted through from the inside. The coating was on the whole well preserved. The pipe was finished and put in use in 1875 and the small holes were discovered in 1901. The pipe is still in use, is 38 ins. in diameter, and has always run full.

Mr. Kuichling also observed another instance of a pipe 24 ins. in diameter, of riveted sheet iron, of mediocre quality, coated the same as the last mentioned pipe. It was put in position in 1874 and entirely uncovered recently. The sheet iron is ⅛-in. thick. It was found in good condition; the coating is well preserved. The pipe is still in use. It was uncovered because the engineer believed it must certainly be rusted through; he therefore intended to replace it by a cast-iron pipe. This was not done because no defects could be found.

These are exceptionally favorable instances, probably due to the fact that the coating was very rigidly inspected. The latter pipe was full for only two weeks every year; for the rest of the time it was empty.

Ships' bottoms on the Lakes are exposed in a similar manner to the inside of water pipes running full. They are, however, frequently painted, and it is not known how much difference this makes. The United States put the little ship "Michigan" on the Lakes in 1843. Her plates are ¼-in thick and she is still running.

Mr. Freeman states that ⅜-in. riveted pipe, if inspected and recoated every ten years, will last fifty years. Effective recoating with asphalt would, however, hardly be practicable without removing the pipe from the trench. It is essential that the pipe be dry, otherwise the coating will not adhere. The amount of oxygen in the water and probably the velocity of the water in the pipe will influence its longevity. If the water is not pure the nature of the admixtures, whether alkaline or acid, will also have great influence. In a talk with Mr. Sabin, the inventor of the Sabin pipe coating, he informed me that the water in Niagara River contains carbonate of lime, which is alkaline; it is therefore not hard on pipes. Fishes obtain a large supply of oxygen by forcing water past absorbing surfaces. Since the velocity of water in our pipe far exceeds the usual velocities (it is about 3 to 5 times as large) there may be more oxidation and its life may be much less than that of other pipes.

If the pipe has a cement mortar coat on the inside, this coat, even if not perfectly waterproof, will greatly retard the change in the water which touches the surface of the steel; the mortar will absorb its carbonic and other acids and the rusting on the inside will be extremely slow if not entirely negligible.

In France, steel in armored concrete pipes was found perfectly bright after 14 years' use of the pipes. Iron in Roman concrete was found well preserved after about 2,000 years.

There can be no doubt that the concrete would preserve the steel from rust on the inside of the pipe. It would, however, be very desirable to know from more observations how rapidly the rusting of an asphalt coated pipe will proceed if it is always running full. This rusting may be so slow that a concrete lining is unnecessary. The evidence which I could gather is inadequate to decide this question with certainty. . . . . The concrete lining, if used, will offer the additional advantage that the pipe will be much tighter and will remain good, even with spots of considerable size rusted through from the outside. If you build a pipe without concrete lining, ⅜-in. thick, and well coated with asphalt and tar, I believe from the information I have gathered that it will last at least 35 to 40 years. If this pipe has a durable cement coating inside I believe it will last at least 50 years. . . . . .

All statements here made referring to the life of pipes are only true if there is no electrolysis.

Referring to the coating for the outside of the pipe, the following facts are of interest.

According to "La Revue Technique," cement paint is largely used by the railway companies of France to protect the ironwork of bridges from rust and corrosion due to the steam and sulphurous gases from locomotives. The iron is brushed with leather brooms, dampened, and given two coats of liquid cement and sand.

At Zeebrugge, Belgium, steel piles are cleaned by sand blast and coated with semi-fluid cement mortar applied by compressed air.

According to C. T. Purdy "the engineers of the Boston Subway after investigation and careful tests adopted Portland cement paint for the protection of the steel beams of the structure."

Dr. Goslich, at the 1901 meeting of the German Portland Cement Manufacturers' Association, stated that "iron spirit tanks painted on the inside with Portland cement, are universally employed in European distil-

*Consulting Engineer, 1 Broadway, New York City.

leries. The adhesion is increased by allowing the metal to become rusty before applying the cement paint and perfect protection from further rusting is secured."

Cement is a durable, chemically stable, inorganic substance, hardening and remaining hard in either water or air, not harmfully affected by either; it adheres well to steel, has practically the same coefficient of expansion from changes of temperature. It is not water-tight, but it will prevent the circulation of the water over the bare surface of the metal, and will therefore greatly retard rust. . . . .

Since asphalt is not uniformly satisfactory I feel inclined to follow the example of the Boston subway and of French and German engineers, and to use two coats of cement and fine sand for the outside of the pipe, if its inside is to be lined with cement mortar.

Dr. Goslich is nearly alone in recommending the use of a cement coat after the pipe is rusted. Most experts insist that no rust should be on the metal before the coat of paint is applied. . . . . The builders of concrete and steel structures use the steel without a coat of paint and assert that a little rust is rather an advantage and will produce better adhesion. They therefore confirm Dr. Goslich. . . . .

I have also investigated the Sabin pipe coating—a baked coat of Gilsonite, linseed oil and mineral gum. It has been used in Rochester with good results, because it was carefully made; also in Cambridge and Allegheny. It is also used for protecting pipes on United States war vessels, where it withstands hot sea water very well. It was first used in 1893. It would cost much more than other coats because the baking would require a very large oven in our case. It is of too recent invention to have given proof that it will stand better than the unbaked coats of asphalt and tar.

The ordinary coat of asphalt and tar consists of refined Trinidad asphalt and tar pitch. Tar pitch answers well for the purpose; it can be obtained in the market in large quantities, while tar is sometimes not so easily obtainable when large amounts are required. The coating for both sides costs on small pipes about 2½ cts. per sq. ft. of plate. This would make $1.42 per lin. ft. of our pipe, if the unusual size does not increase the cost of handling.

Mr. Kuichling, who has experimented a good deal with various coatings, believes that mineral rubber, an unbaked coat of similar ingredients to the Sabin pipe coating, is the best coating, judged by its appearance, but I do not believe that it has been thoroughly tested by use.

. . . . . .

To guard against electrolysis the finished pipe was finally connected by wires to the rails of the trolley line and by them to the negative poles of the dynamos.

DESIGNING A LARGE PIPE TO RESIST DEFORMATION.

It was most important to secure a safe pipe that would not crack or collapse under any one of the different depths and kinds of covering materials. The writer was soon convinced that a riveted steel pipe with stiffening rings was the proper type under all the circumstances. The chief engineer of the power plant, whose past experience was in the West, was a persistent advocate of a stave pipe. One bidder proposed a pipe made of ⅝-in. plates with lap joints without stiffening rings. Masonry saddles for supporting the pipe were also advocated and discussed.

The writer was asked for his opinion on all these propositions by General Edmund Hayes, the Vice-President and at that time the General Manager of the Ontario Power Co., who had practically taken charge of the design and execution of the pipe line. He was justified by events in his belief that the extensive experience of General Hayes in the design and execution of steel structures and his sound judgment would lead to the adoption of any recommendation for which conclusive scientific reasons could be advanced. The lessons which can be drawn from executed structures depend to a great extent on a complete understanding of the reasons which led to the adoption of their fundamental features. Each buried structure is the product of local conditions and would be generally unsuitable in another place. The reasons which lead to the adoption of its several features are alone of more frequent application and are of value as a future guide. The writer therefore believes a complete statement of these reasons more instructive than a mere description.

The records of successful structures showed some penstocks of 12 ft. diameter made of ⅝-in. plates without stiffening rings. The records of failures gave many cast-iron pipes failing by longitudinal cracks from unexplained causes, generally accompanied with flattening but not with total collapse. The inference drawn from these records, which showed pipes of the same strength behaving quite differently under apparently similar circumstances, was that careful tamping of the surrounding material greatly assists the pipe in keeping its shape under large pressures, acting both downward and upward. With the ordinary sizes of large cast-iron pipes it is difficult to prevent cracking along lines parallel to the axis. Where this cracking must be prevented a cast-iron pipe 18 ft. in diameter would be impracticable on account of excessive cost.

Wrought steel pipes of large diameter often flatten but do not crack and the harm done is limited to a reduction of capacity. The surrounding earth evidently yields only to a limited extent, and after this offers much larger resistance to further displacement, thus preventing the rupture of a flexible pipe. This quality of wrought iron or steel explains the success with steel pipes much thinner than would be inferred adequate from the experience with cast-iron pipes and from the relative strength of the materials, were the ultimate forces to which they are subjected the same. A round pipe exposed to forces acting normal to it is under compression if these forces are alike along its circumference. If the forces acting on different parts of the circumference are different, or not normal to the surface, there arises a tendency to deformation. In a large buried pipe at moderate depth there is tension at the outside of the wall at the ends of the horizontal diameters and compression at the inside. The section through the axis of a short length of the pipe or a ring, say 1 in. long, transmits not only a compression but also a bending moment. The former is due to the uniform normal outside pressures, the latter to deviations from uniformity of pressure or normal direction. The resistance of the pipe element or ring here considered against the bending moment tending to distort it is proportional to the moment of resistance of its half-section through the axis of the pipe and to the strength of the material. In the case of a cylindrical shell of uniform thickness

$$M = \frac{K d^2}{6},$$

where M is the moment transmitted by the section, d is the thickness of the shell and K is the strain per square inch in the extreme fiber produced by the moment M. If the uniform normal outside pressure is p lbs. per square inch then the uniform pressure per square inch in pipe wall is

$$K' = \frac{p r}{d},$$

where r is the outside radius of the pipe. In our case K′ is very small, is easy to determine and need not further detain us. In a riveted pipe reinforced by stiffening angles the ring considered must be of such length that a succession of equal rings will make up the pipe.

On pipes submerged in a liquid the liquid above the top of the pipe produces uniform normal pressures over the surface. The liquid between top and bottom level of pipe produces gradually increasing pressures on parts of the surface, according to their distance from the top. These latter pressures produce the deforming bending moments. It is evident that the total amount of these latter pressures is proportional to the square of the diameter of the pipe and their distorting moment is proportional to the cube of this diameter.

In earth the amount of the pressures arising from the weight of the material alongside the pipe, and the law of their increase, are not the same as in a liquid, but the difference in pressure per unit of area on points at the same angular distance, of pipes of different diameter, will evidently be proportional to the diameter of the pipes. So are the areas exposed to pressure, and the average leverages of the pressures on one side of any axial section of the pipes. The product of the three is proportional to the deforming moment arising from the material alongside the pipe and to the third power of the diameter. The ability of pipes to resist such distorting moments should therefore be proportional to the third power of their diameters. For pipes of the same material the ability to resist distorting moments is proportional to the moments of resistance per unit of length of the axial half section of a ring of such length that it will properly represent the pipe. From this it follows that the moment of resistance of the axial half sections of pipes of different diameters should be proportional to the cube of their diameters. This rule will give pipes of equal capacity to resist the distorting moments arising from the unequal pressure of the material between top and bottom of pipe. The material above the top of the pipe will, if it is water, produce uniform normal pressures on the pipe, which can easily be calculated. The strains arising therefrom are, with a pipe of large diameter and near the surface, comparatively small and can easily be allowed for. If this material is earth, the strains cannot be calculated, but it will by its weight increase the friction preventing motion of the material around the pipe and will thereby help to prevent deformation of the pipe. A deeply buried pipe, within moderate limits of depth, is safer than one near the surface. The numerous recorded failures of cast-iron pipes show that they generally fail where the depth of covering is the least. This is undoubtedly at least partly due to the fact that the strength of cast iron in compression is much greater than that in tension. A moderate uniform initial compression in the pipe will therefore increase its capacity to resist bending moments tending to deformation. A wrought-steel pipe does not possess this advantage, but it can stand considerable deformation without cracking; it will therefore more certainly gain in safety against rupture from any cause which will increase the friction in the surrounding material and thereby prevent its displacement.

For these reasons it is believed that the above rule that the moment of resistance of the axial half section of pipe should increase as the cube of the diameter is an approximate guide for determining from the strength of successful buried pipes the strength required for pipes of larger diameter for which no experience exists. By this guide one would infer that a plain cylindrical shell 18 ft. in diameter should have metal 5.2 times as thick as a shell 6 ft. in diameter. This clearly shows the impracticability of a plain cast-iron pipe, which is, however, evident from other reasons. If a pipe made of ⅜-in. plates is considered sufficient for 9 ft. diameter, one of 18 ft. diameter should have plates

$$\tfrac{3}{8}\sqrt{2^3} = 2.83 \times \tfrac{3}{8} = 1.06 \text{ ins.}$$

thick. If the former is considered sufficient for 12 ft. diameter one of 0.58-in. thickness would be equally adequate for 18 ft. diameter.

The writer thought a 12-ft. diameter pipe made of ⅜-in. plates without stiffening rings, in spite of a known successful precedent, too risky a structure to recommend. He therefore condemned a proposed design for a pipe 18 ft. in diameter, made of ⅝-in. plates, as not sufficiently safe. It is easy to obtain at much less cost by the use of stiffening rings and thinner plates a pipe several times as strong, which will therefore give an abundant factor of safety. A pipe made of rings 8 ft. long, consisting each of three plates ½-in. thick with double riveted lap joints and stiffened by 7-in. deck beams 20 lbs. per foot, 4 ft. apart, and extending over the upper half of the pipe and 2 ft. beyond on each side, was finally adopted. The soil was drained by a tile drain under the pipe and a layer of concrete of varying thickness was applied at the outside.

At an earlier stage of the controversy the use of masonry saddles was advocated by some and contested by the writer in a report which follows.

ARGUMENT AGAINST THE USE OF MASONRY SADDLES.

In a perfect liquid the pressures acting on one of its elements are dependent on the depth of this element below the surface and upon the specific gravity of the liquid. The pressures are equal in all directions. If a solid body is submerged in such a liquid it loses a part of its weight, equal to the weight of the liquid displaced. This loss is due to the fact that the pressure on the lower surface is larger than that on the upper one. Such a body will therefore rise to the surface if its specific gravity is less and it will sink to the bottom if it is more than that of the liquid. If we consider now a solid body, like rock or steel, under the influence of gravity or a superincumbent load, we find that the active pressure exerted by it is a vertical pressure. By active pressure I mean such a pressure as will follow a receding resistance. As long as the load on a solid body does not exceed the compressive strength of the material a vertical column of it will stand, and be in equilibrium if the base on which it rests is able to carry the load. It is therefore evident that by a solid body, under the limitations given above, the pressures are transmitted only in the direction in which they act. If no adequate opposition is met in this direction the body moves as a whole. It does not spread laterally to any considerable extent as long as the compressive strength of the body is not exceeded by the forces acting on it.

Between the properties of liquids and solids lie those of a material composed of small particles with the voids either empty or filled with a liquid. These properties approach more nearly to the one or other extreme according to the shape, size, specific gravity and roughness of the particles, and the amount and specific gravity of the liquid in the mixture. If the liquid has equal or greater specific gravity than the solid particles, and is abundant in quantity, and if the latter are small, smooth and round, the whole mixture will in its behavior more nearly approach a liquid than a solid body. A specifically heavy body, especially if large, will sink in the mixture as in a liquid, though its motion will be slower; a specifically light body will rise. This shows that pressures in such a mixture slowly tend to become equal in all directions. A viscid liquid like mucilage has similar properties. The main difference between a perfect and a viscid liquid is the greater slowness of displacements produced in the latter by given forces. Swampy ground behaves nearly like a viscid liquid. Railway embankments filled on swampy ground produce a rise of the ground on both sides and a sinking of the embankments. If a large solid body is submerged in a viscid liquid it will slowly rise if of less specific gravity than the liquid, especially if the motion is assisted by vibrations, and if the difference in specific gravity is large.

A heap of sand behaves differently from a solid or liquid. It has a certain maximum natural slope, if acted

on by its own weight, only. This shows that the pressures at a given point are not equal in all directions. They are largest in a vertical direction and less in directions deviating largely from the vertical. If a heap of sand is heavily loaded the maximum slope becomes flatter and may even become an upward slope. A post may be forced into the sand and the surface alongside will rise. Experiments, however, have shown that the resistance opposed to the sinking of a post in dry fine sand increases about as the square of the depth of lower end of post below the surface of the sand. This indicates that dry sand can only with great difficulty be displaced by pressure when loaded even to a moderate extent. The same applies to coarse wet sand. I have, as consulting engineer of the Butterick Building, at Spring and Macdougal Sts., in New York City, made experiments to ascertain the carrying capacity of fine and coarse sand saturated with water. We wanted the foundation to carry safely eight tons per sq. ft. The ground water and the cellar floor were 22 ft. below the street level. Fine sand extended to about 35 ft. below street level. We sunk an 8-ft. long tube to a depth of 6 ft. below the cellar floor. The tube was 12 1-16 ins. square in the clear. We filled in 6 ft. of sand around the tube. We inserted a 12 × 12-in. planed post into the planed and greased tube, and loaded the post. It sank about ⅛-in. with eight tons load, but more than an inch with a load of 12 tons. The post rested on fine sand, saturated with water. The sand was evidently forced from under the post. We repeated the experiment, but went down to the coarse sand with the base of the post. It carried 34 tons without a settlement of more than about ⅛-in. This shows that coarse sand saturated with water can practically not be displaced if the surrounding sand is under considerable load.

The natural maximum slope of wet sand is much flatter than that of dry sand; that of very fine sand is much flatter than that of coarse sand.

A mixture of sand and water has some qualities in common with a viscid liquid, but differs from it in some important respects. A large solid body will rise in a viscid liquid if its specific gravity is less than that of the liquid. But a large solid body may be lighter than a mixture of sand and water of equal volume and it will not rise in it.

We shall consider a cube of 1 cu. ft. with the upper surface coinciding with the surface of the sand saturated with water. The pressures acting on the vertical sides, being horizontal and balancing each other, will not produce any motion. On the lower surface will act the hydrostatic pressure of the water corresponding to the depth of 1 ft. This will be equal to the weight of 1 cu. ft. of water. The sand will exert no active upward pressure. The cube, if it is as heavy as water, will certainly not rise, since its weight balances the total upward pressure. To rise, the cube would have to be much lighter than water, since motion could only take place if the resultant upward force would exceed the starting friction between it and the adjacent sand. If the upper surface of the cube is below the surface of the mixture then we have acting on the top surface the weight of the sand and water above it, and on the bottom surface acts only the hydrostatic pressure corresponding to the depth of the lower surface. The specific gravity of the saturated mixture of sand and water is two. If the upper surface of the cube of 1 ft. side is 1 ft. below the surface of the mixture then the active downward pressure on it is equal to the active upward pressure on the lower surface. The cube in this case would not rise even if it had no weight and if there were no side friction. If the submerged cube has the same specific gravity as the mixture of sand and water, that is about two, then the pressure on the sand exerted by the lower surface of it is just the same as it was before the cube was introduced. If there was equilibrium before its introduction there will be equilibrium afterwards. No special foundation below the cube is therefore required for supporting it, however large the cube may be, if its specific gravity is not more than that of the mixture. The same argument can be used for a body of any shape by imagining it decomposed into an infinite number of vertical prisms.

After this preliminary general discussion we are prepared to discuss our special case of the buried pipe. The material excavated will be either rock, or coarse sand and gravel, or quicksand, or sand with clay. It will in most places, at least in the lower part of the ditch, be saturated with water. If the material below the excavation is of such a kind that it does not rise on account of the pressure from the higher surface of the ground on both sides of the ditch, and if it stands at a fairly steep slope, the ditch will be dug without the use of sheet piling. If we meet quicksand or muck that will not stand a steep slope, sheet piles will have to be used at both or possibly only on one side of the ditch. These sheet piles will have to be driven deep enough to avoid the rising of the ground at the bottom of the ditch. The ditch will be drained during the construction of the pipe, but after the pipe is constructed the space around it may become saturated with water. Each lineal foot of pipe will weigh when full of water about 17,400 lbs. less than the wet material which it displaces. The ground below it will therefore carry, after the pipe is constructed and full of water, about 970 lbs. less load per square foot than it carried before our operations began, unless the final level of the surface is higher than the original one. This level would have to be raised more than 7 ft. to make up for this difference. There is therefore not the slightest danger that the pipe will ever sink. If there is any bodily motion of the whole pipe in soft ground it will rise. To put a foundation below it, as is done below a pipe on the surface, would therefore be unreasonable and based on a false analogy. It may be advisable in very soft ground, if any is met, to put a few feet of gravel below the pipe to secure stiffness and prevent flattening of the pipe but not to prevent its sinking. We see pipes resting in saddles on the surface; this experience influences our feelings in this matter and contractors and practical men who do not stop to analyze the forces acting on a structure before constructing it will recommend saddles.

During the erection of the pipe there was some trouble which called forth a final report by the writer on the stability of the pipe, which report here follows.

ON THE STABILITY OF THE 18-FT. DIAMETER BURIED WATER PIPE.

If a pipe made of thin plates is exposed to outside normal pressures of uniform amount per square foot around the whole circumference these pressures produce compression in the plates. The resultant compressions pass through the center of the plates and there is no tendency to deformation, with the exception of a small reduction of the diameter. If the empty pipe is submerged in water the outside pressures acting on it increase with the depth below the surface. These unequal pressures tend to produce deformation and a lifting of the whole pipe if the displaced water weighs more than the material of the pipe.

It is evident that there is no equilibrium. The pipe would have to be anchored and the deforming forces would depend on the kind of attachment of the anchorage. If the pipe is buried in mud instead of water then the pressure on the highest part of the pipe, which pressure acts vertically downwards, is equal to the weight of the mud above. At the ends of the horizontal diameter the normal pressure on the pipe is horizontal. This horizontal pressure per square foot is not as large as the weight of a prism of 1 sq. ft. extending to the surface of the mud. The vertical pressure of mud at any part of its interior is equal to the weight of the mud above; the horizontal pressure is much smaller. In soft mud this horizontal pressure is somewhat larger than in water. Mud weighs about twice as much as water. If the mud is very thick, the horizontal pressure is little more than half the vertical pressure.

At the bottom of the pipe the normal pressure is upward; it is about equal to the hydrostatic pressure at equal depth. The downward pressure in the mud at some distance, but at the same level, is about twice the hydrostatic pressure corresponding to the depth.

If the material is dry earth, or sand, the pressure at the ends of the horizontal diameter is only from ⅓ to 0.4 that in water at equal depth. This is the amount of the active pressure that tends to crush the pipe and follow the yielding pipe wall. The dry earth or sand at the ends of the horizontal diameter of the pipe, opposes, however, a resistance 20 to 50 times as large as the active pressure to the lengthening of the horizontal diameter. This enormous difference between active and passive pressure, or the pressure pushing out from and that opposing the pushing in of the material, is very important for the stability of the pipe.

In water there is no such difference. The difference is small in soft plastic clay. Plastic clay is slow to move, but the active and passive pressure in a horizontal direction are not very different in amount. In sand, even if wet, especially if the sand is coarse, there is a great difference between active and passive horizontal pressure.

In dry filling material there is even a considerable difference between the active and passive pressure at the top of the pipe where the active pressure of the material acts downwards.

At the bottom of the pipe a dry filling material would not follow the receding pipe wall. The active pressure is, therefore, 0. The passive pressure, that opposing the sinking of the pipe, is larger than the weight of the material above points near by and at the same level.

No part of the circumference of the pipe can be forced in without forcing out other parts of the circumference. Where the circumference is forced in the active pressure of the surrounding material acts. Where the circumference is forced out the passive pressure of the material acts.

The circumference can only be forced in where the pressure is larger than on other parts of the circumference. Since the active pressure does the forcing in and the passive pressure resists the forcing out, forcing in can only take place if the active pressure at one part of the circumference is larger than the passive pressure at some other part. In all dry materials the passive pressure which opposes deformation is enormously larger than the active pressure producing deformation. Of wet materials coarse sand, gravel and broken stone have the greatest difference between active and passive pressure; plastic clay has the least difference. The former gives, therefore, the greatest, the latter, the least stability of all wet materials. After these general considerations we are prepared to consider special cases.

The worst case we have to consider is a pipe buried in plastic clay saturated with water to the surface, the top of the pipe being 3 ft. below surface, the pipe being empty.

If the clay were perfectly plastic, the active and passive pressure at any point would be nearly the same; it would behave nearly like water excepting that all motions would be very slow. The specific gravity of wet clay is about two. All pressures would, therefore, be about twice as large as in water. The normal pressures on the pipe would increase from top to bottom nearly in proportion to the depth. The pipe would slowly rise, since the friction would not be as large as the lifting force. The pressure on the bottom being largest, the bottom would bulge in. In such material there would be no reason for not stiffening the lower half of pipe.

Perfectly plastic clay does not, however, exist on our site; our filling material is at the worst places largely mixed with sand. In such material the active and passive pressures are different.

Wherever, during the excavation of the ditch, the material does not rise from the bottom it is evident that the active upward pressure of the uncovered material is nothing. If in such places a covering is introduced which prevents the escape of the water, then the active upward pressure may approximate the hydrostatic pressure of the water at a depth equal to that from the point considered to the neighboring ground water level. It would be equal to this hydrostatic pressure if the water were standing in the space near and above the point considered. If the water is slowly moving downward through the material above the point considered, then the pressure at this point must be less than the hydrostatic pressure corresponding to the depth by a sufficient amount for overcoming the friction opposing the flow.

The passive pressure at the bottom of the pipe is more than the load above nearby places at the same level, and is, therefore, more than the largest load which it will have to carry, since the weight of the full pipe is less than that of the displaced material. The accepted formulas for earth pressure against vertical retaining walls show that even at the ends of the horizontal diameter the active pressure in wet earth is no more than the hydrostatic pressure corresponding to the depth. Along the lower half of the pipe the active pressure is, therefore, at most, approximately equal to the hydrostatic pressure corresponding to the depth. The passive pressure is, even at the ends of the horizontal diameter, much more than the active pressure at the bottom of the pipe. No bulging can, therefore, occur if the total pressure on the upper half is at least equal to the total pressure on the lower half, and if the upper half is sufficiently stiffened to distribute unequal loads. Larger active pressures than here assumed can, however, be artificially produced, either by tamping or by swelling of the material. Clay that is not perfectly saturated with water will swell when it becomes fully saturated. This swelling would produce much greater pressure than the hydrostatic pressure corresponding to the depth. It or excessive pressures produced by tamping might cause buckling during erection. It is considered extremely bad practice to fill in the back of retaining walls with clay that is not perfectly saturated with water, since the clay in becoming saturated is apt to force the wall out.

If the water in the neighborhood of the pipe were absolutely at rest, the material being perfectly soaked to the surface, there would be at the bottom of the pipe an active pressure per square foot of at least $21 \times 62.5 = 1{,}312.5$ lbs.

This active pressure would have the effect of making the shell press outward with an equal pressure, not only at the bottom of the pipe, but also for some distance up along the circumference. If the friction between the shell and soil is negligible, the pressure between the shell of the unstiffened lower half of the pipe and the surrounding soil is uniform. The total upward pressure on the lower half of the pipe becomes then per lineal foot of pipe $1{,}312.5 \times 18 = 23{,}625$ lbs.

The weight per lineal foot of the material above the pipe is $(34.76 + 54)\ 125 = 11{,}095$ lbs. The weight of the pipe is 1,500 lbs. This gives a total weight of 12,595 lbs. per ft. The upward pressure is 23,625 lbs., which is 11,030 lbs. more than the weight carried. To rise, the pipe must shear along two surfaces of 12 sq. ft. each. The shearing stress in these surfaces is 464 lbs. per sq. ft. The average pressure in these surfaces is 750 lbs. per sq. ft. The shearing force is not sufficient to overcome the friction.

We have here neglected the friction between the pipe wall and the surrounding material and have assumed that the water is standing while saturating the soil to the surface and thus exerting the full hydrostatic pressure on the bottom of the pipe. In reality, the water

in the soil is probably nowhere, for any considerable length along the pipe, absolutely at rest. The forces acting upward have, therefore, been exaggerated, and a lifting of the empty pipe need not be feared even if it is covered with less than 3 ft. of soil. Wherever the covering above the top of the pipe is more than 3 ft. thick, the factor of safety against its rise rapidly increases.

Any increase in the depth of the covering, even if this is saturated with water, increases the passive pressures much more than the active ones, and, therefore, increases the stability.

EQUILIBRIUM OF PIPE IN DRAINED MATERIAL.—To secure good drainage and to avoid danger from eventual stoppage of drainage, the filling material along the lower half of the pipe should be coarse sand or gravel containing less clay than the volume of the voids.

If we consider the empty pipe in such material we have no active pressure of the surrounding material at the bottom of the pipe. The largest active pressure will be near the ends of the horizontal diameter; this is less than 0.4 the hydrostatic pressure corresponding to the depth below the surface. The passive pressure, even at the top of the pipe, is larger than this. With well drained filling material hardly any stiffening would be required after the filling is completed.

If the pipe in dry filling material is filled with water, which weighs about ⅝ as much as the surrounding filling material of equal volume, all the stresses are reduced to about ⅝ of those in the empty pipe.

STABILITY DURING FILLING.—While the material is being filled in along the lower half of the circumference, the only downward force acting on the pipe is its weight and such forces as are transmitted from neighboring buried parts of the pipe by its acting as a girder. The active upward forces should, therefore, be kept small until the whole filling is completed. If the filling material along the lower half is porous and drained then water may be used without harm for settling it; if the material is clay or very rich in clay so as to be nearly water tight, the liberal use of water may produce large active upward forces and may overstrain the pipe during construction and may even produce buckling. With well drained filling material the largest active pressures exerted on the pipe are near the horizontal diameter. If these forces produce a reduction of this diameter horizontal struts should be temporarily introduced and removed after the filling is completed.

The pipe is stiff enough for undrained filling, but drainage will very much increase the factor of safety and will greatly facilitate the placing of a neighboring pipe. As long as deformation of the pipe is prevented by the fact that the least passive pressure on the shell is larger than the greatest active pressure, the pressure in the steel shell due to the weight of the material above the pipe with 8 ft. depth above top of pipe does not exceed 2,000 lbs. per sq. in. This direct pressure is, therefore, unimportant as compared with the stresses which would arise if deformation were not prevented by the nature of the filling material.

Where the top of the pipe is only 3 ft. below the surface the passive pressure at the top is less than the largest active pressure produced by soaked filling material. The stiffening half rings are, therefore, needed with undrained filling material. If one could with certainty count on efficient drainage an unstiffened pipe would be stable.

My advice remains, therefore, substantially the same as previously given: Use coarse sand or gravel for filling along lower half of pipe, drain this material, and use, if necessary, temporary horizontal struts inside the pipe.

The most extensive discussion took place in regard to a proposed stave pipe, made of California redwood staves. Staves 6 ins., then 8 ins. and later 10 ins. thick, were proposed. The writer inferred from the records of previously constructed pipes that the staves must be at least 10.4 ins. thick to make as strong a pipe as the weakest of those that proved successful and thought it unadvisable to use staves less than 12 ins. thick if the usual type of pipe with steel bands was used. In a report on the durability of timber stave pipes he reached the conclusion that a pipe like the one proposed, made of thick staves exposed to small inside water pressure, buried partly above ground water level, would have but small durability unless it was imbedded in clay kept moist by water artifically supplied. The cost of a sufficiently strong pipe made of thick California redwood staves would have been more than that of a steel pipe.

The stave pipe proposed was of the ordinary type, with steel bands to bring the staves under compression. Where the pipe is buried 10 ft. deep the load of earth produces this compression and at the same time a slackening of the bands. The deformation of the pipe is then resisted mainly by the increase in compression at the outside of the stave joints, where the diameter is shortened by the deforming forces and at the inside where the diameter is lengthened. The safe compressive strength of water-soaked timber against forces acting normal to the fibers, as in this case, is at most 200 lbs. per sq. in.; against forces acting along the fibers it is about six times as much. To advantageously use timber for obtaining a stave pipe it should be so placed that the forces act in the direction of the fibers. The writer therefore advocated the use of thin staves, held together by steel bands and stiffened by means of plank rings. The rings were each composed of three layers of planks: A center layer of eight 4 × 16-in. planks butting against each other and forming an octagon; on each side of this a layer of eight 2 × 16-in. planks with their centers at the ends of the 4-in. planks; the whole bolted together by 96 ⅞-in. diameter bolts, with cast washers. These rings were to be placed at distances of from 5 to 8 ft. to be determined by experiment. The filling material for the lower three-quarter of depth of pipe was to be gravel, and above this clay kept wet by water coming from small holes in the top staves of the pipe. The planks above ground water level were California redwood sinker stock; the rest white pine. Such a pipe made of 3-in. staves would have required less than half as much timber as an ordinary stave pipe equally strong made of 12-in. staves. The rods theoretically required to produce a pressure in the stave joints equal to the largest inside water pressure would have been one-quarter as many as in an ordinary stave pipe. The staves would have been more durable because thinner and more probably fully water-soaked than thick staves. The topmost planks of the stiffening rings could have been replaced with the pipe in use. Since the timber was to be always moist no shrinking and consequent loosening of the bolts was to be feared.

A serious objection against both types of stave pipes was that the steps taken to obtain their durability by keeping them wet might produce a swampy surface. The principal objection against stiffening plank rings is that they are new and untried; the same objection applies, however, to any kind of stave pipe of this diameter.

An experimental stave pipe of the ordinary type, made of 8-in. staves, was built and proved inadequate upon test. There was no [illegible] for further experiments and the writer [illegible] not sorry when the decision was reached to [illegible] to a steel pipe. With the design finally [illegible] there was reasonable certainty that [it] would prove successful without further experi[ments].

The steel pipe at Niagara Falls has [been in] use for some time without trouble of any [kind] so far as known to the writer.

RECENT EXPERIENCE WITH SUPERHEATED S[TEAM] ON CANADIAN PACIFIC RY. LOCOMOTIVES.*

By H. H. Vaughan,† M. Am. Soc. [M.]

In the paper read at the last meeting of the [Master] Mechanics' Association,‡ four types of superheat[er] were described, the "Schmidt" smoke-box, the "Schm[idt] fire-tube, the "Pielock" and the "Schenectady" fir[e-tube], of which the "Pielock" had not been used in Amer[ica], while the other types were in use on the Canadian [Pa]cific Railway on the following types and numbers of [engines]:

Type of Superheater.	Class of Engine.	Number Equipped.	Weight of Engine.	Size of Cylinders.	Size of Drivers.	Type of Engine.
Schmidt smoke-box	548	1	120,000	18 x 24	63″	10 wheel s[imple].
Schmidt fire tube	1,000	1	172,000	22 and 33x26	63″	10 "
" "	1,300	1	192,000	22 and 35x30	63″	10 "
" "	1,600	20	186,000	21 x 28	63″	Consolidation simple.
Schenectady	1,621	21	186,000	21 x 28	63″	"

Since that time a number of other engines have been equipped with superheaters, all except one being of new construction. The types of superheaters used are the Schmidt fire-tube, a modification of the Schenectady, which may be called the Schenectady B, and one designed by Mr. A. W. Horsey, Mechanical Engineer of the Canadian Pacific, and the writer which will be called the "C. P. R." The complete list of engines so equipped follows, those marked X being on order and not yet delivered:

Type of Superheater.	Class of Engine.	Number Equipped.	Weight of Engine.	Size of Cylinders.	Size of Drivers.	Type of Engine.
Schmidt	700	10	190,000	21 x 28	63″	10 wheel simple.
Schenectady B	710	55	"	"	"	" "
C. P. R.	740	30	"	"	"	" "
C. P. R.	820	1	164,000	20 x 26	69″	" "
C. P. R	780	5	190,000	21 x 28	63″	" " W. F.
C. P. R.	1,150	3	215,000	"	69″	Pacific.
X. C. P. R.	7,000	15	190,000	"	63″	10 wheel simple.
X. C. P. R.	1,100	3	215,000	"	75″	Pacific.
X. C. P. R.	1,640	20	185,000	"	57″	Consolidation simple.

From the list it will be seen that in addition to the 44 engines in service last June, 104 engines have been built or equipped with superheaters, which, with the 38 on order, makes a total of 186 engines built or being built of the superheater type.

The design of the "Schmidt" fire-tube and "Schenectady" superheaters has been so fully illustrated in the technical press and in the writer's previous paper that it is unnecessary to illustrate them here. The only alteration made in the "Schmidt" design has been the substitution of separate bolting for each flange connecting the superheater pipes to the header in place of using clips as in the original design. This has entirely overcome the trouble from leakage previously experienced, and while a small change, is a considerable improvement.

The "Schenectady" superheater used on the 1621 class employed the "Field" tube type of superheater pipe in which steam is led from the saturated steam header through the small tube to the rear end of an inch and three-quarter tube attached to the superheated steam

*Extracts from a paper read before the New York Railroad Club, April 20, 1906.

†Asst. to Vice-Pres., C. P. Ry., Montreal, P. Q.

‡Engineering News, June 22, 1905.

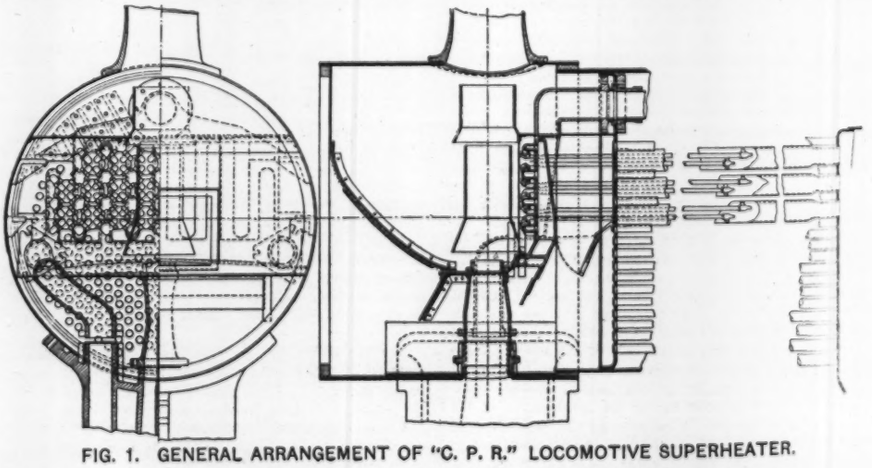

FIG. 1. GENERAL ARRANGEMENT OF "C. P. R." LOCOMOTIVE SUPERHEATER.

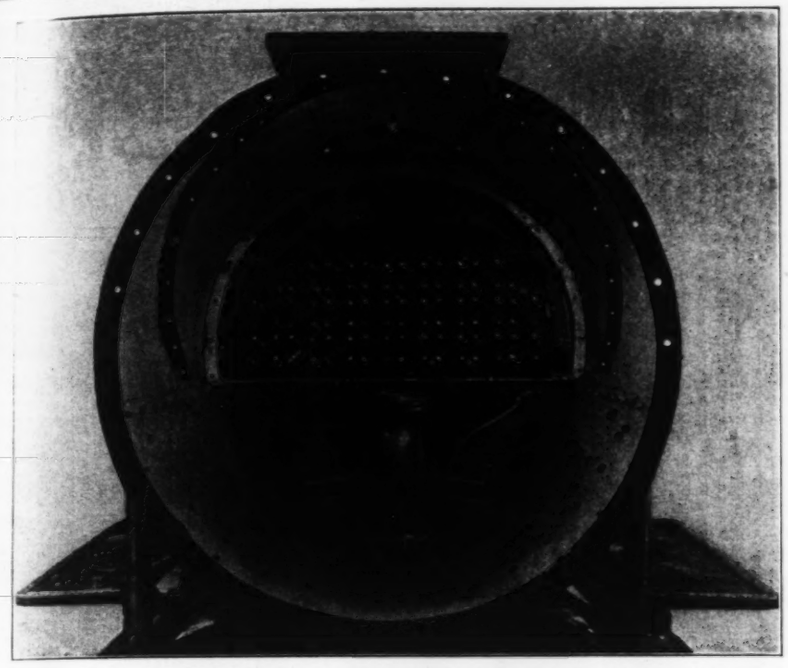

FIG 2. VIEW INSIDE FRONT END OF LOCOMOTIVE WITH "C. P. R." SUPERHEATER.

header. The fire-tubes are 3½ ins. in diameter and each contains one 1¾-in. superheater pipe. In the "Schenectady B" type of superheater, with which the 710 class engines are equipped, the well-known design of "Schenectady" header is retained, but the superheater pipe and fire-tube arrangement is the same as in the "Schmidt" and C. P. R. design, namely 22 fire-tubes 5 ins. in diameter, each containing four 1⅛-in. superheater pipes of which the back ends are connected in pairs by return bends while the front ends are connected in pairs to the saturated and superheated steam headers respectively. This design was also illustrated in the writer's previous paper.

The "C. P. R." superheater with which the 820, 740, 780 and 1150 class engines are fitted, is not so well known and on that account the writer hopes that its illustration will be regarded as justified.

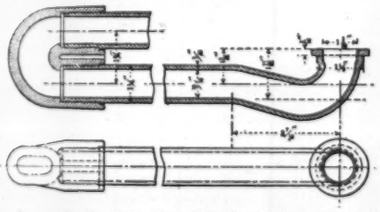

Fig. 3. "C. P. R." Superheater Tubes, Showing Upset End and Connection to Return Bend.

The arrangement of the front end, and of the superheater tubes is shown in Figs. 1 and 2. Steam from the dry pipe enters the top or saturated steam header shown in detail in Fig. 4 and flows through the fingers of the header into 1¼-in. solid drawn weldless steel tubes, inside diameter 1⅛-in. These tubes are upset at one end and are forged and bent by a bolt header and bending machine to the shape shown in Fig. 3. They are connected by bronze union nuts to special cast-steel fittings which screw into the header; a 1/16-in. copper wire gasket being used in the union nut. As shown in Fig. 1 these small tubes extend into large 5-in. superheater fire-tubes to within about 30 ins. of the back tube sheet where they connect with the heavy cast-steel return bends. The steam returns from the return bend through 1¼-in. tubes, which connect through union nuts and special cast-steel fittings, similar to those mentioned above, with the fingers of the bottom-header, which is shown in detail in Fig. 5. The steam pipes which connect this header with the cylinder casting are necessarily very short; however, there has been no difficulty in making the joints tight. Each large superheater fire-tube contains two of the small tubes from the top header and the corresponding return tubes to the low header. The return bend has lugs cast on it, which spaces it properly from the sides of the large tube and the other set of small tubes so that there is a uniform circulation space about the small tubes. The cast-steel return bend is made especially heavy at that part which comes in contact with the smoke and gases from the fire-box.

It will be seen that the "Schmidt," "Schenectady" and "C. P. R." superheaters now being applied on the Canadian Pacific are identical in every respect with the exception of the arrangement of the headers and the connection to them of the superheater pipes. The primary object sought in the design of the "C. P. R." type were the separation of the joints from the heater pipes to the headers, the location of these joints in a position where they could be conveniently inspected and an arrangement of the superheater pipes that would permit any individual element being removed or applied without disturbing the others. These objects appeared desirable after the experience on earlier engines and it is evident they have been very satisfactorily obtained. The first is also satisfactorily met in the "Schmidt" by the separate bolting of the superheater pipe flangers to the header and its need did not develop to any great extent in the earlier engines with the "Schenectady" although later experience would suggest its necessity, as more or less trouble is developing with the joints between the superheater pipe and main headers.

Both the second and third requirements are also partially met by the "Schmidt," but not as thoroughly as in the "C. P. R." design and in both respects the "Schenectady" is deficient. It must not be understood that either of these types give especial trouble in service or are difficult to maintain, in fact the reverse is the case, but the points mentioned are conveniences and advantages which are believed to have been obtained by the modification illustrated and their value will be appreciated from the roundhouse point of view.

The two general classes of superheaters, consolidations and ten-wheel freight engines, can only, on the Canadian Pacific, be compared with compound engines as there are no simple freight engines in use on that road at all similar in size or design. Compounding has during the past few years become firmly established for freight service, and on account of the high cost of coal there would be no question as to its continuance had not the use of superheaters been introduced.

In comparing road coal records a good many difficulties

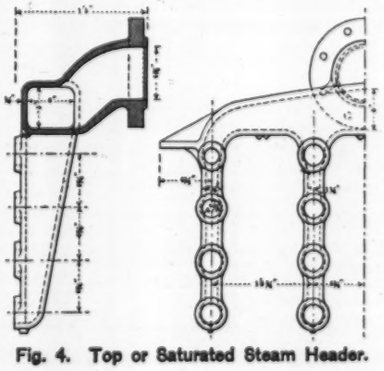

Fig. 4. Top or Saturated Steam Header.

are met with, some of which are usual on all roads, while others apply particularly to the Canadian Pacific Railway. The easiest figures to arrive at, those based on general averages, are not by any means reliable, and considerable study is necessary to ascertain the actual result. The consumption per 1,000 equivalent gross ton-miles or as it may preferably be called per unit-mile varies considerably on different sections on account of the difference in profile, the consumption on the same section varies with the weather conditions, increasing from 25% to 50% in winter over that required in summer; and also varies under the same weather conditions with the proportion between east and west-bound traffic.

The remainder of Mr. Vaughan's paper is devoted to detailed tables of coal consumption of the various superheater engines in service compared with ordinary compound locomotives. These tables show that the engines with the "Schmidt" superheaters obtain only about 20° of superheat and are not quite as economical as the compounds. The engines with the "Schenectady" superheaters obtain 80° to 100° of superheat and show a considerably higher economy than the compounds. The engines with the "C. P. R." superheater showed still higher economy, which appears to be due to a still higher degree of superheat, reaching in some cases 200°. In passenger service the superheater locomotive is also showing up well and the paper concludes as follows:

There is but little doubt that the superheater is very satisfactory and economical in passenger service, and its relative economy does not decrease with increase of speed as is the case with compounds. The repair question is so far unimportant and nothing has developed to show that superheater engines will exceed appreciably simple engines when expenses that are fairly due to experimental construction are excluded. Lubrication on a superheater is identical with that in a simple, with the exception of the additional cylinder connection required, and what is wanted is simply to deliver the oil to the required spot.

In conclusion the writer sees no reason to change the opinion previously arrived at that the superheater steam locomotive attains equal or greater economy than the compound without any of its disadvantages, and would now add to this by stating that the employment of higher temperatures with the still further economy is relatively practical and to that on engines now under construction the proportions of superheating surface will be increased to attain this result. It is especially advantageous in passenger service and so far no counterbalancing disadvantages have been developed which are worth considering. Whether this is due to special conditions on the Canadian Pacific Railway or not superheating is certainly successful on this road, and there is so far no inclination to discontinue it.

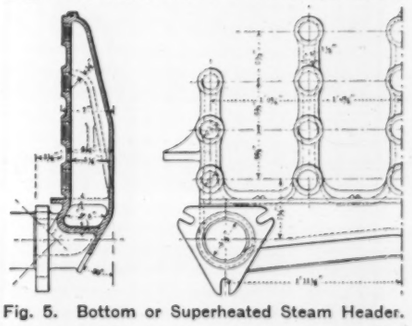

Fig. 5. Bottom or Superheated Steam Header.

THE PRODUCTION OF ANTHRACITE COAL for the year 1905 was the largest in the history of the anthracite industry, and amounted to 69,339,152 long tons. Of this amount 61,654,432 tons were shipped to market, 1,402,644 tons were sold about the mines locally, and 6,282,076 tons were used for steam and heat. The New England States, New York, Pennsylvania and New Jersey, consumed over 80% of the coal marketed, the Southern States 3½%, and Canada nearly 4%, leaving a balance of only about 11%, which was shipped to points west of Buffalo, Erie, Pittsburg or corresponding points. It is interesting to note that while the per capita consumption of anthracite coal in the New England States, New York, Pennsylvania and New Jersey, was in 1891 about 1.71 tons, it had increased in 1905 to 2.16 tons. This increase is largely accounted for by the great increase in the quantity of pea and smaller sizes of coal shipped in 1905 as compared with 1891. Therefore disregarding these small sizes in order to get the per capita consumption of domestic sizes we have for 1891, 1.22 tons, while for 1905 it amounts to only 1.11 tons. Thus it is seen that the relative consumption of anthracite in these states is greater than 15 years ago, if all sizes are considered, but small if only the domestic sizes are included.

DIAGRAMS FOR THE STRENGTH OF STEEL AND WOODEN COLUMNS.

By Louis Ross.*

The strength of a column of given length depends not only on its cross-sectional area, but also on the least dimension of its cross-section. In designing a column the length and the required strength are known. The design consists in selecting such a section that the cross-sectional area shall be a minimum, and that the combined effect of the area and least dimension of the section shall supply the required strength. Since the area required depends on the least dimension, and the least dimension allowable depends on the area, the design must be made by the trial and error method. Each trial involves the solution of a more or less complicated equation; the process is therefore tedious.

The diagrams reproduced in Figs. 1 and 2 have been designed by the writer to facilitate this trial process. Placing a triangle in the proper position across the diagram and making one reading solves automatically the particular column formula chosen by the designer, so that each shift of the triangle corresponds to a new trial. This not only saves mental work, but also makes the effect of the varying factors evident to the eye of the designer.

The following example will show how to use this form of diagram: Let the load on the column be 40,000 lbs. and its length 15 ft. It is required to find the proper section of a rectangular and also of a square wooden column. In the diagram for wooden columns, Fig. 1, find the curve marked 15 ft.; try a least dimension of 6 ins. by placing triangle as shown in position abc; this gives an area of 89 sq. ins., which is too much out of proportion. Try a least dimension of 8 ins. by sliding triangle to position $a_1 b_1 c_1$, always keeping the right angle of the triangle on the column curve; this gives an area of 72 sq. ins., for which an 8 by 9 will do. Shift the triangle slightly further to 8½, when the side of a square is also found to be 8½ ins.

For steel columns the radius of gyration must be first computed. In the first few trials this radius of gyration may be taken approximately only. The required area as shown by the diagram is compared with the actual area from the Handbook, to see whether the section is too strong or not strong enough. As an example, suppose a load of 60,000 lbs. is to be supported by a column 20 ft. long, the column consisting of two latticed channels. Try an 8-in. 11.25-lbs. channel having a radius of gyration of 3.1 ins., by placing the triangle in position $a_1 b_1 c_1$ (Fig. 2); the area required shown by "d_1" is 5.2 sq. ins., while the area as given in the Handbook is 6.7 sq. ins., which is too large. Try a 7-in. 9.75-lbs. channel having a radius of gyration of 2.7, by placing triangle in position a b c, giving a required area of 6 sq. ins., while the actual area is 5.7 sq. ins., which is slightly weak.

*Assistant Engineer, U. S. Geological Survey, Washington, D. C.

(1) $f = \dfrac{800}{1 + \frac{1}{1100}\frac{l^2}{d^2}}$ (2) $f = 800 \times \dfrac{700 + 15\frac{l}{d}}{700 + 15\frac{l}{d} + (\frac{l}{d})^2}$ [U.S. Forestry Formula]

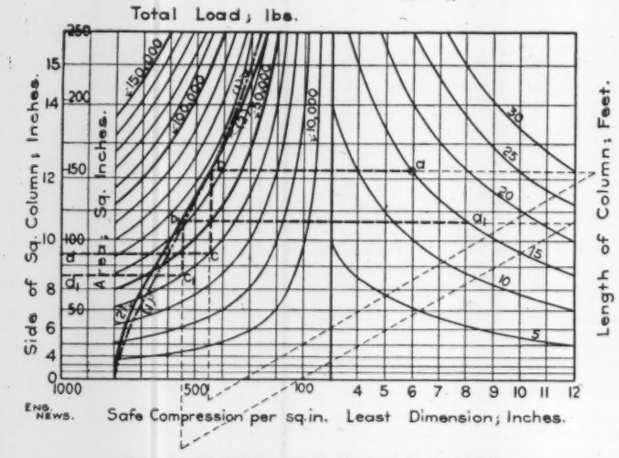

FIG. 1. DIAGRAM FOR WOODEN COLUMNS.

$$f = \frac{16{,}000}{1 + \frac{1}{18{,}000}\frac{l^2}{r^2}}$$

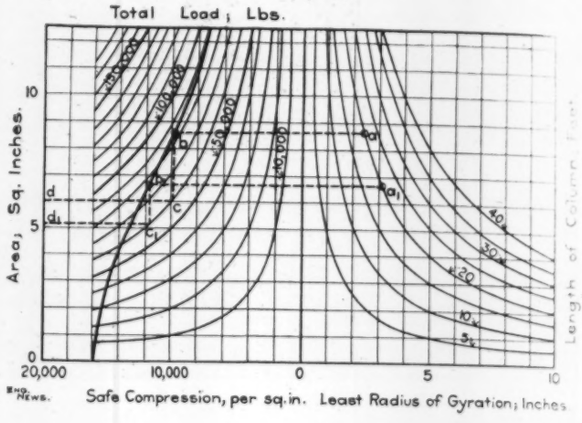

FIG. 2. DIAGRAM FOR STEEL COLUMNS.

Column Curve 1, $f = \dfrac{800}{1 + \frac{1}{1100}\frac{l^2}{d^2}}$

Column Curve 2, $f = 800\,\dfrac{700 + 15\frac{l}{d}}{700 + 15\frac{l}{d} + \frac{l^2}{d^2}}$

(U. S. Forestry Formula.)

Column Curve, $f = \dfrac{16{,}000}{1 + \frac{1}{18{,}000}\frac{l^2}{r^2}}$

(a) A column formula curve is first plotted against $\frac{1}{r}$ as an argument for steel, and against $\frac{1}{d}$ for wooden columns. The formulas plotted by the writer were:

For steel—

$$f = \frac{16{,}000}{1 + \frac{1}{18{,}000}\frac{l^2}{r^2}}.$$

For wood—

$$f = \frac{800}{1 + \frac{1}{1{,}100}\frac{l^2}{d^2}}.$$

and $f = 300 \times \dfrac{700 + \frac{15\,l}{d}}{700 + 15\frac{1}{d} + \frac{l^2}{d^2}}$ (U. S. Forestry formula.)

but any others may be substituted or added.

(b) The length curves are then drawn on the right half of the diagram. These are all equilateral hyperbolas, since $\frac{1}{r} \times r$ or $\frac{1}{d} \times d$ is a constant.

(c) Next the load curves are drawn. These are also equilateral hyperbolas, since the constant total load equals the product of the area of section by safe unit compression.

IRRIGATION SURVEYS ON THE SHOSHO[NE] [IN]DIAN Reservation are now being made by three [par]ties under the direction of Mr. Clarence T. Johnston, State [Engi]neer of Wyoming. The reservation is to be thrown [open] for settlement on Aug. 8, and as no one can [enter] the lands until they are irrigated the state authorities are very anxious to make provision for irrigation before these surveys could be made it was necessary to obtain the consent of the Secretary of the Interior. This consent was secured only a short time ago. It is hoped that by the middle of July, 1906, maps and [data] will be on file in the office of the State Engineer, showing the location of irrigable lands and irrigation works, accompanied by detailed plans and estimates of cost of every important structure needed. Investors will then be requested to submit propositions for the construction of canals and reservoirs. The bids must state the price per acre at which permanent water rights will be disposed of to settlers. The State Engineer of Wyoming has control of the waters of the streams of the state, and no permits will be issued by him for the irrigation of the country covered by the state projects except to the persons with whom contracts are made for building the necessary works. Further information may be obtained by addressing Mr. Johnston as above.

ALL SPEED RECORDS IN TUNNELING will be smashed by the O'Rourke Construction Co., which is boring the Pennsylvania Railroad tubes under the North River. Begun in February, 1905, the tunnel will be finished inside of three months, which will be more than a year sooner than the time specified in the contract.

Floods of inquiries are daily being made concerning the methods which make such remarkable speed possible. No details of the work will be made public by the O'Rourke Construction Co., however, until the work is completed and the company relieved from all responsibility. In the contract there is a provision which states that in no circumstances shall the company furnish any information concerning the work. Engineers who are familiar with the work, however, assert that engineering and scientific circles will be greatly surprised when they learn what discoveries have been made by the O'Rourke Co. in the construction of the Pennsylvania tunnels. New devices and new methods for boring at great depth which will be of inestimable value in all future tunnel work have been discovered, it is said.

Only 300 ft., approximately, now intervene between the headings, and within a month it is expected the tubes will be almost joined. Encouraged by the swift progress of the work, the engineers in charge of it are bending energy to complete it in the shortest possible time, so that a record for tunnel building may be established.

Boring from the New York side of the river started at Eleventh Ave., although the tunnel proper will have its beginning at Tenth Ave. Under the river the engineers encountered rock and shale, but chiefly mud. Work on the two tubes progressed with about equal speed, and those starting from this side of the river are now a little beyond the middle of the stream. They run 25 ft. apart. The plan is to have one track in each.

Weehawken was the starting point of the shafts from the New Jersey side. Work on them is equally advanced and they are close to the middle of the river. Concurrent with the reports of almost magical progress under the North River there are rumors of delay in the work under the East River. The Pearson Company of England has the contract for these tunnels and they have been compelled to bore through almost solid rock from the time they sank the first shafts. Work on the tunnel under Manhattan Island is progressing with satisfactory speed, and the tunnel under Bergen Hill from Weehawken, which is being dug by William Bradley, is being pushed ahead rapidly. The principal delay, it is said, will be in completing the terminal between Seventh and Ninth Aves.—New York Herald, April 12.

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The greatest conflagration ever recorded has laid waste the city of San Francisco and destroyed the homes of more than half its people. The conflagration was caused, as our readers know, by the earthquake which visited California on the morning of April 18 and did great damage to other cities of Central California as well as to San Francisco. According to present information, however, the property damage wrought by the earthquake was trifling compared with that resulting from the fire which followed. The earthquake appears to have started a number of fires in wrecked buildings and at the same time so damaged either the street mains or the supply the water supply. There was nothing to do, therefore, but let the fire burn itself out, although attempts were made to check its course by blowing up buildings with dynamite. This appears to have been wholly fruitless, however, and the conflagration raged, apparently with little hindrance, from Wednesday morning until Thursday night, while isolated fires continued to do more or less damage apparently until Sunday night. Practically the entire business district of the city was swept by the flames as well as a large proportion of the closely built up residential section. The interruption to telegraph, mail and newsgathering facilities has been such that accurate statements as to the area burned over are not yet possible; but seven square miles appears to be a conservative estimate.

The lesson indelibly impressed on the American public, we hope, and surely on every engineer, is that the very existence of every large city in the United States depends absolutely on the existence of its water supply. The failure of water supply is not a matter of mere inconvenience or temporary suffering, or interruption of industry. In every great city in this country an interruption of the water supply places the city in great jeopardy of total destruction by fire.

It should be especially understood that American cities stand on a different plane in this respect from the cities of England or the Continent. Perhaps just as good buildings of fireproof construction may be put up to-day in New York as in London or Vienna; but it is not the buildings of to-day or to-morrow that create the conflagration hazard. It is the great multitude of ordinary structures, built anywhere from five to fifty years ago; and at least 99% of these buildings in American cities are built with the prevailing type of wooden stud walls and partitions, which is the distinctive bane and curse of American building construction.

San Francisco, notwithstanding numerous examples of high-class construction in business blocks and residences, was substantially a city of wooden buildings; and while the Pacific coast timbers are doubtless less readily inflammable than the white pine with which the Chicago of 1872 was constructed, it made no difference in the spread of the conflagration.

Not until our cities are made up of structures as incombustible as those of Paris or Vienna can we escape the condition that our cities' existence will depend on the presence of an unfailing water supply and an eternally vigilant fire department. The engineering profession will watch with interest for the lessons to be learned from this great catastrophe and we hope to present much matter of this sort to our readers in future issues. Elsewhere in this issue is given a summary of the great disaster in as much detail as it can be presented at this time.

Of course the newspaper accounts which are thus far our only source of information contain little comparatively of the technical information which the engineer desires, and that little of doubtful reliability. So far as we can see, however, the results of the earthquake appear to be reassuring as to the ability of engineers by substantial construction to withstand an earth tremor of considerable intensity.

It is true, certainly, that given an earthquake sufficiently severe, such as have occurred at very rare intervals, in the vicinity of active volcanoes, any artificial work of man would be likely to perish. In San Francisco, however, while the shock was sufficient apparently to overturn furniture in rooms, a number of the steel frame buildings seem to have survived the earthquake with comparatively little injury, and are now being occupied, notwithstanding fire damages, in lack of better quarters. Apparently, too, the well built residences suffered comparatively little, the great loss of life occurring in the collapse of cheap lodging houses and hotels, probably structures of flimsy construction such as are apt to fail to this sort of use in every city.

A matter of immediate interest, of course, concerns the effect of the earthquake on dams, reservoirs or other engineering works, in view of the attitude of the critics who have favored a sea-level canal at Panama on the ground that any other would be subject to earthquake damage. While our information is at present of a negative sort, it is at least interesting that no destruction or serious injury to any of the numerous high dams in the vicinity of San Francisco has been reported. So, too, we have no information of any damage to the stone and concrete dry docks at the Mare Island Navy Yard, structures enough like canal locks to form a good precedent for the resistance of a canal lock to an earth tremor.

An 18-ft. riveted steel pipe on which is to depend a large power plant is so notable a piece of engineering construction that we need make no apology for devoting several pages of this issue to studies made preliminary to and in connection with its design. These studies, by Mr. Joseph Mayer, M. Am. Soc. C. E., deal first with the protection of the pipe against rust and its probable life; next with its design to resist deformation; then with the stability of so large a pipe when buried; and finally with a consideration of the availability or the reverse of redwood staves for constructing the conduit. The pipe under discussion, which has now been in successful use for some time, was built for the Ontario Power Co., of Niagara Falls. It is composed of ½-in. steel plates, with double-riveted lap joints. The pipe is stiffened by 7-in. deck beams (20 lbs. per ft.), 4 ft. c. to c., extending over the upper half of the pipe and 2 ft. beyond on each side. The soil was well drained by tile laid beneath the pipe, and a layer of concrete of varying thickness was applied outside the pipe. We leave to our readers a discussion of the numerous interesting points raised by Mr. Mayer's article.

A hitherto unknown genius in Omaha, Neb., has favored us with a circular advertising "four great inventions for sale," which he lists and prices as follows:

1. A stove or furnace that will furnish the same heat or hot air by using only 1-6 part of the coal.
2. A new steam boiler with a fuel saving of 400%.
3. The harnessing of the power of gravitation; to run dynamos, or produce electricity without the use of coal or steam power.
4. A new motor to produce electricity or run dynamos by reharnessing the lost 85% of coal power that now goes out of the chimney.

Copies of the original drawings of these great inventions can be had as follows: No. 1 for $100; No. 2, $150; No. 3, $200, and No. 4, $300.

The inventor has evidently chosen the psychological moment when a coal strike is in force to offer the fruits of his genius to the public. It looks to us as if his steam boiler, which can make a fuel saving of 400%, ought to keep its owner supplied with at least enough coal to run a retail yard.

Under the heading, "Scope of Inventions," the inventor dilates on his "gravitation engine" as follows:

> The value of water power, especially by harnessing water falls of colossal dimensions, has been well appreciated of late, but in a water fall it is more the power of gravitation that comes into play than the water proper and it is the natural power of gravitation that has almost entirely lost its importance nowadays, although some two or three thousand years ago it was a well-known appliance. By not attempting to harness gravitation in a manner similar to water power, I mean on a colossal scale, all modern attempts to use that power have failed because in small models the friction is greater than the weight of the whole engine and even the air helps to stop such "small potato" machines. Hence, I say that only my machine will work the other way and is as permanent as the metal entering into its construction.
>
> About the harnessing of the power of gravitation I will only say, I made and destroyed in sheer rage three models, because they had a decided tendency to run the other way than calculated. I believed in the lever—theory, but I find that the spokes of a wheel cannot be taken for levers, because the rim neutralizes them and being a lover of astronomy and being persuaded that while our planets run around the sun as the center of gravitation of this single system, the world at large, with its uncounted for sun-systems, runs around an invisible center and this is the new theory that explains to me clearly why my models wanted to run the other way, and they would have done so had they not been so small, cheap and incumbered by useless friction. Now my Gravitation Motor is 18 ft. high and the wheel running the belt to harness dynamos is 15 ft. 4½ ins. in diameter, and you can see at a glance that 13 weights will run down on one side and raise 5 weights up the other side, thus realizing the old idea of perpetual motion, in spite of all the backguard professors and eyeglassed bookworms. There are more things between heaven and earth which that two-legged animal "man" has not seen yet, but which can make him great.

The struggles of perpetual motion inventors through all the ages in trying to make the 13 weights running down on one side raise the 5 weights on the other side are well known; and it is cheering news that this Omaha genius has at length got the better of the professors and bookworms who have all along insisted it was impossible.

The article on the tie and timber preserving plant of the Atchison, Topeka & Santa Fe Ry. at Somerville, Tex., announced on our front-cover bulletin, is postponed to a following issue, the change in arrangement being decided on after the cover forms went to press.

SOME WATER SUPPLY AND FIRE PROTECTION LESSONS FROM THE SAN FRANCISCO EARTHQUAKE AND FIRE.

The great conflagration at San Francisco, following the earthquake of April 18, adds interest and force to the recent Underwriter reports on water supply and fire protection at New York, Chicago and Detroit, abstracted elsewhere in this issue. In each of the reports named much-needed improvements in the water-works and fire department services and great possible reductions in the conflagration hazards are pointed out. In the case of New York it is urged that there is extreme danger of shortage in the water supply before the proposed additional supply is available, and it is also urged that the separate fire main system now under construction be extended throughout a large part of Manhattan Borough and that the minimum pressure in other districts be materially increased. New lines of large feeding mains, more shut-off valves for the control of breaks in the water mains and more efficient fire hydrants, and water waste preventive measures, are strongly recommended for all three cities. Higher pressures at both Chicago and Detroit are also advised. Building law revisions,

studies of electrolysis, the more general establishment of fire sprinkler systems, and better protection of window and other openings are recommended for each of the cities.

So far as we know, little heed has yet been given to these reports in either New York or Chicago (the Detroit report is just out), but the smoldering ruins of San Francisco should awaken not only these cities, but every city in the land as well, to look to their water supply and fire protection as never before. The measures that should be taken at once to reduce the fire risks in a large number of cities have been indicated by a long series of reports on cities large and small, well distributed through the United States, made during the last two years or so by the Committee of Twenty of the National Board of Fire Underwriters. In the face of its great misfortune we hesitate to say that as recently as October, 1905, San Francisco was warned of many of its water supply and fire protection needs in a report by the Committee of Twenty. But as another warning to the other communities already named by reports from this committee we call attention to the concluding portion of our abstract, elsewhere in this issue, of the San Francisco report, which abstract has been prepared especially for this issue since the fatal earthquake and conflagration in that city. The last sentences of the report may well be quoted here:

> In fact, San Francisco has violated all underwriting traditions and precedent by not burning up. That it has not done so is largely due to the vigilance of the fire department, which cannot be relied upon indefinitely to stave off the inevitable.

We would by no means say here that San Francisco could have averted its awful disaster by any possible action, since last October, on any or all the Underwriters' recommendations, but it is perfectly obvious that well-directed efforts, extending over say the last five years, would have greatly increased the fire fighting chances after the recent earthquake shock.. We say this not as a reproach to San Francisco, but as a warning to other cities. Obviously no city can effectually guard itself against a severe earthquake, and quite as obviously but few American cities need to do so; but every city has conflagration hazards which it can do much to reduce, and every city practically surrounded by water can afford itself double fire protection by the separate fire main service already installed in Boston, Philadelphia and in a number of cities on the Great Lakes, now under construction for a portion of New York and under consideration at San Francisco when the investigations were being made there in behalf of the Committee of Twenty.

Under severe earthquake conditions it is of course possible that a separate fire main service at San Francisco, even if supplied with salt water from the bay or from the ocean, would have been as helplessly crippled as was the regular waterworks system of that city; but had there been separate fire mains, supplied from the Pacific, the chances of having water to fight the fires would probably have been at least doubled. Under any other but earthquake conditions, or in 999 out of a thousand cases, a salt water fire protection system would most assuredly afford double safeguards.

Fire boats alone, with ample hose equipment, would have been of inestimable service at San Francisco. The city had none of these, but the California State Harbor Commission had two tugs, equipped with fire pumps. Oakland, just across the bay, was also without fire boats, so that although its fire department went to the aid of San Francisco it could do little but add men to a fire department already working, it seems, with little or no apparatus. Had the two cities together been able to muster three or four powerful fire boats, with plenty of hose, great aid might have been rendered by these means.

What San Francisco did have that many cities lack was (1) several independent sources of water supply, well inter-connected, and (2) a number of distributing reservoirs, with gravity supply mains feeding the pipe distribution system. Under almost any but earthquake conditions these would be powerful factors in controlling a great conflagration, and they will doubtless prove of inestimable value in restoring the water supply and fire protection of San Francisco. Cities dependent on a single supply conduit, or upon a single pumping station, with little or no storage in either case, may well shudder when they think what would happen in case the one conduit or pumping station was wrecked. Even where fairly ample storage is provided, some of our smaller cities dependent on pumping use a single main to force water to and draw water from their reservoir; that is, employ a direct pumping system, and pass the surplus of pumpage over consumption to the reservoir, the latter to be drawn upon when the consumption exceeds the pumpage or when the pumps are for any reason shut down. The moral is obvious.

San Francisco had a considerable number of fire cisterns in the older part of the city. It will be interesting to learn whether these were of material service. Perhaps they were wrecked by the earthquake, or rendered inaccessible by debris. Even if drawn upon they would very soon have been exhausted.

Far more interesting will it be to learn the relative effect of the earthquake upon cast iron and wrought iron water mains within the city, and upon the wrought iron pipe, the wooden flumes and the masonry conduits making up the several main water supply conduits leading to the city. But above all engineers will be eager to know the effect, if any, of the earthquake shocks upon the two high earth dams and the great concrete dam, forming a part of the San Francisco waterworks; the earth dams being nearly and the concrete dam more than 100 ft. high above the natural surface. Reports from other earth and masonry dams in California will be awaited with great interest.

We seize this opportunity to point out, chiefly as a warning for the benefit of the general public, since most engineers know it full well, the utter helplessness and hopelessness of the modern city when its public water supply is cut off. If a fire breaks out the city is at the mercy of the winds, and if it once gains headway the fire may be said to spread on the wings of its own wind. Dreadful as the fire risk is when the water supply fails, that calamity scarcely compares with the other attendant dangers, the greatest of all of which may be brain crazing thirst. The conditions are rare, however, at least in nearly all American cities, where enough water cannot soon be secured to quench thirst; but it should be remembered that dangerous thirst is a matter of scarcely more than hours and that under the heat and tense excitement of fire natural thirst is speedily aggravated. In the long run water enough to quench thirst is bound to be secured, or else the place abandoned or depopulated by death. This, however, will not avert a whole series of calamities; first, the certainty that where drinking water is scarce and disorder prevalent many people will drink polluted water; and second, that lack of water for household purposes, including use in water closets, will give rise to the accumulations of both ordinary filth and decomposing fecal matter. Under such conditions, obviously, water closets should not be used, but it is not easy to prevent this, and even with extraordinary public sanitary control it would be difficult to prevent other and almost as dangerous nuisances; namely, accumulations of fecal matter out-of-doors which, in the summer time or during the whole year in warm climates, will afford an opportunity for the spread of typhoid fever by means of flies, exactly as happened, though quite needlessly, at our military camps during the Spanish-American war. Besides these graver dangers a host of others, many of which are minor only by comparison, follow the failure of a city water supply, including, of course, the practical cessation of all industry.

And yet in face of so many and so grave dangers hundreds of our cities would have a water famine of longer or shorter duration if a single supply main or aqueduct should break, a dam or reservoir fail, or a pumping station burn. Moreover, there are hundreds of cities and towns that would suffer more or less severely should the rainfall approach at all closely to the lowest on record.

The foregoing statements may seem severe, but they are full of deep significance; and that too, because in the popular mind [illegible] rarely pictured as possibilities, even [illegible] day of postponement of urgently [illegible] works improvements makes them more likely to become probabilities. To [illegible] can think of no better example than [illegible] meaning but utterly fallacious arguments of certain New Yorkers who at hearings on the proposed new Catskill water supply urged that an additional supply was quite unnecessary because some thousands of millions of gallons of water were wasted over the Croton dam last year. The economic and physical impracticability of providing storage for the whole flow of a river never seemed to occur to these people.

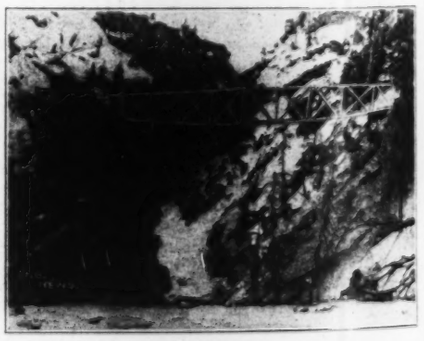
Every great public calamity, in so far as it might have been averted or lessened by precautionary measures, teaches its lesson both to the community affected and to all others that might be affected by a disaster of like kind or merely related in some of its primary or secondary effects. As for lessons from the earthquake direct, we are not here concerned. As for water supply, and fire protection, we can only add to what has been said, and that merely for emphasis, that it behooves every city in the land to make good the deficiencies in both which its authorities know full well, or not knowing should take immediate steps to ascertain with the aid of the best engineers the country affords. This remark applies with especial force to New York City, which has already lost years of valuable time since the several engineers' reports following the Ramapo steal agitation showed the urgency of immediate measures to reinforce the water supply of the American metropolis. Happily, active work on surveys and plans for an additional supply is now being pushed by scores of the ablest engineers in the United States, but the relief to be afforded by works thus being provided for is so distant that there is the utmost need for carrying out at once numerous supplementary measures, in connection with both the water and fire departments and in reducing the conflagration hazards in numerous ways.

LETTERS TO THE EDITOR

An Alaskan Suspension Bridge.

Sir: I send a photograph of a very light suspension bridge built across Placer River Canyon, 52 miles north of Seward, Alaska, on the line of the Alaska Central Ry., now under construction.

The bridge is of 120-ft. span. Two ¾-in. cables, over which was built a light truss, span the canyon. The top and bottom cords are a single row of 2 × 6-in. spruce, the web members are 2 × 4-in. pieces bolted to the cords. The truss is 10 ft. deep in the center and 7 ft. at the ends. The bridge was built to give foot passengers from the camps access to the tunnel work on the other side of the canyon and to carry the air pipes from the compressor; 1,600 lbs. of equipment in one load have, however, been transported over this bridge without any appreciable deflection. After the bridge was erected two other ¾-in cables were run through, starting at the top of the truss at each end to stiffen up the truss latterly, and these top cables carry some portion of the weight of the bridge. This bridge is 125 ft. from the bottom of the canyon.



A 120-Ft. Span Suspension Foot Bridge in Alaska.

Yours truly,

J. B. Cameron,
Engineer of Construction, Alaska Central Railway Co.
Seward, Alaska, March 15, 1906.

Names for Section Subdivisions.

Sir: In answer to Mr. Gillett, in your issue of April 12, I will say, as an old government surveyor, that the corners are designated by the government as "section corners, quarter section corners and sixteenth corners." The sixteenth corners are so called for the reason they divide the section into 16 parts.

The corner at the center of the section where the north and south, and east and west quarter lines cross, is a quarter post, or c. ¼ post. These were our instructions at least in dividing Indian lands in 1880 to 1890.

In a late number, reference was made by some one to S. V. Clevenger's book on government surveying as being very instructive. In my opinion it is not of much account; the tables for the use of Burt's solar compass were wrong.

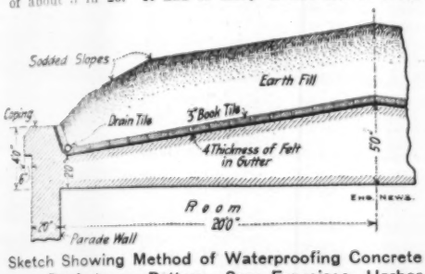
R. J. Mershon.

1317 W. 105th St., Chicago, Ill., April 14, 1906.

Waterproofing Concrete Roofs, San Francisco Harbor Fortification Work.

Sir: Referring to the article in Engineering News of March 15 on the subject of water-tight concrete roofs, I beg to add to the contribution by quoting the experience had in the local harbor on fortification work.

The style of roof protection illustrated was first tried here in 1902. The type of roof was a particularly hard one to make water tight as the thickness of the concrete near the parade wall could not be made more than 24 ins., while at the ridge it was but 5 ft., giving a pitch of about 3 in 20. It had to carry in addition an earth



Sketch Showing Method of Waterproofing Concrete Roof to a Battery, San Francisco Harbor Fortifications.

traverse of about 6 ft. of earth. From the years of previous experience it had been learned that the only way to prevent percolation was to remove the water and moisture as soon as it penetrated the earth fill. Since expansion and setting checks and cracks always appeared in the masonry (generally disregarding the provided expansion joints) in a few years after erection a pliable roof covering was considered necessary.

The concrete was troweled to a fairly smooth surface, was mopped with a heavy coat of roofing asphaltum, or mastic, then covered with the heaviest grade roofing felt laid 3 ply, starting at the coping of the parade wall and made 4 ply in the gutter. On this assumed water-tight surface 3-in. book tile was laid with joints normal to the gutter and cemented. The purpose of the tile was to afford a free passage for the water as soon as it met the roof. The expectations were fully realized and no water, or even a sign of moisture, has appeared in this battery, or at another of the same type since built, after a fair test of time.

The construction noted in the aforementioned article of March 15 differs in no way from the one just described excepting that 1 in. of hydroline was placed under the felt course instead of the concrete being merely mopped with mastic. The total cost of the local work, including mastic felt and tile was 17 cts. per sq. ft. on a job of 6,200 sq. ft., coving three roofs. The writer was the assistant engineer on the work.

Yours respectfully,

J. H. G. Wolf.

1099 Pine St., San Francisco, Cal., April 4, 1903.

Foundations for Concrete Arches and the Charley Creek Bridge.

Sir: In your issue of April 5 Mr. Gayler criticizes the usual footing designs for concrete arches with particular application to the Charley Creek Bridge at Wabash, Ind. Mr. Gayler has drawn a reasonable assumption from the plans, but an erroneous one, when he assumes that the bridge is not founded on rock. The bridge spans a ravine with a small stream near one bank, which rarely rises high enough to reach the footings, and rock appears within a foot or two of the surface across the entire ravine. Under these conditions the footings are very properly designed.

There are, however, several other features of your descriptive article on the Charley Creek Bridge in your issue of March 15 that deserve correction. The bridge was not built by the Trussed Concrete Steel Co., as stated. The contractor was John A. Ross, of Frankfort, Ind.

The curves for the arches were designed as parabolas. Since the parabola is in equilibrium under a uniform horizontal load, while the loading on this bridge varies upwards of 300% from uniformity, being about 500 lbs. per ft. at crown and 3,000 lbs. at haunches, the selection of a parabolic curve is only a makeshift presumably chosen by the designer to lighten his labors of analysis. In other words, not being able to decide on the proper curve he has chosen the most inappropriate one because it is the easiest to analyze.

Your description also states that the arch was analyzed by Greene's Graphic Method. Strictly speaking this cannot be correct, for Greene's methods show no analysis for a parabolic arch except with thickness increasing as the secant of the angle of inclination, and this section does not even approximate such an arch. Your drawing seems to show a segment of a circle for extrados with a parabolic intrados, a most unhappy combination.

Mr. Gayler in comparing footings for arches with those for steel and wooden girders seems to overlook the fact that an arch has horizontal thrust. When horizontal as well as vertical forces are taken into consideration it is proper to design the abutments with inclined or stepped footings (provided, of course, that the foundation is not so stratified as to preclude this design), and for such conditions the two figures shown in his article become reasonable rational methods of resisting both the horizontal and vertical thrusts, and are above criticism except as to proportions.

Very truly yours, J. C. Yates.

Frankfort, Ind., April 18, 1906.

The Design of Reinforced Concrete Columns.

Sir: The writer, who has followed with interest the many articles which have appeared in Engineering News and other engineering periodicals during the past three years, dealing with the subject of reinforced concrete construction, has become impressed with the idea that the designing of columns has received but scant consideration. While the action of reinforced beams, under simple loading has been quite fully discussed, both from observations of actual tests and from purely theoretical considerations, the writer can not now call to mind a single article in which there is any record of tests on reinforced columns or a theoretical treatment of their design. Does this lack of literature mean that the subject is too simple, or that the nature of the action of a reinforced column under load is too complicated, to be reduced to working formulas, or simply that the engineering profession, having attacked and conquered, the question of the proper design of beams will soon take up that of columns in its usual thorough and energetic manner?

The writer hopes that the formula which he here presents may evoke enough interest and criticism to lead to a general discussion of the best methods of designing reinforced concrete columns.

In looking over a set of specifications not long since, the following clause relating to concrete columns drew the writer's attention:

"The total load on the column shall be considered to be vertically supported, one-half by the concrete and one-half by the steel, and the safe compressive stresses shall be taken as 350 lbs. per sq. in. in the concrete and 12,000 lbs. per sq. in. in the steel."

Is it justifiable to assume that one-half, or, for that matter, any other definite proportion of the imposed load is taken by the concrete or by the steel? As long as the bond remains intact whatever stress is in the steel is transmitted to it by the concrete (unless the reinforcing of the beams is directly attached to that of the columns), and under the imposed load the column compresses a theoretical amount, which one may call λ. This negative elongation λ is the same in both the concrete and the steel, and the unit stresses in each will be determind by multiplying it by the respective modulus of elasticity. For the sake of the argument let us assume that the ratio of the modulus of steel (Es) in compression, to that of concrete (Ec) in compression, or $\frac{Es}{Ec}$ is equal to 15. Then under any reasonable loading the unit stress in the steel will be 15 times the unit stress in the concrete.

Most authors agree that 500 lbs. per sq. in. is a reasonably safe stress for the extreme fiber on the compression side of a beam. Then may we not assume 500 lbs. per sq. in. as the allowable stress for compression in the concrete of the column? With this assumption the unit stress in the reinforcing will be 500 × 15, or 7,500 lbs. per sq. in. Applying this to the specification quoted above would make the unit stress in the steel 5,250 lbs. per sq. in. instead of 12,000 lbs.

Tests on homogeneous columns show that failure often occurs by a bulging at the circumference or by a diagonal sliding, or shearing action, along a plane inclined at about 45° to the axis of the applied load, when the specimens do not exceed in length 10 times their least side. Theoretically this total shearing force is a maximum along a plane inclined 45° to the axis of the column, and is equal to the total imposed load multiplied by $\frac{1}{2}\sqrt{2}$.

Should not this shearing force be taken into account when designing the vertical reinforcement of columns, and the vertical reinforcing rods be tied together at intervals not exceeding the least side of the columns by rods proportioned to resist the bulging of the circumference?

Let Fig. 1 be the cross-section of a reinforced concrete column whose dimensions are b and d. Let the area of

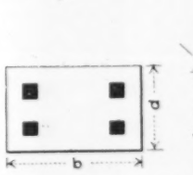


Fig. 1.

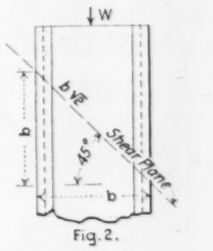


Fig. 2.

steel be represented by p b d. Then area of concrete = b d − p b d = b d (1 − p).

Allowable unit stress in concrete in compression = 500 lbs. = Sc.

Allowable unit stress in steel in compression = Sc $\frac{Es}{Ec}$ = 500 × 15 = 7,500 lbs.

Then safe load taken by concrete = b d (1 − p) 500.

Then safe load taken by steel = p b d 7,500.

Let W (Fig. 2) be the total safe load taken by the column.

Then W = b d (1 − p) 500 + p b d 7,500.

$$\text{Whence } b\,d = \frac{W}{7{,}500p + 500 - 500p} = \frac{W}{7{,}000p + 500}. \quad (1)$$

In Fig. 2 is shown the plane of maximum shearing stress. Total shearing force = ½ W $\sqrt{2}$ = .7 W.

The area of the plane = d b $\sqrt{2}$.

The area of steel = p b d $\sqrt{2}$.

The area of concrete = b d $\sqrt{2}$ − p b d $\sqrt{2}$.

= b d $\sqrt{2}$ (1 − p).

The allowable shearing stress in the concrete will be assumed to be $\frac{1}{10}$ the allowable compressive stress, or 50 lbs. per sq. in. Hence the value of the plane section of concrete in resisting shear is 50 b d $\sqrt{2}$ (1 − p). The safe shearing unit stress on the steel will be taken as 12,000 lbs. per sq. in.

Hence the value of the steel in resisting the shear will be 12,000 p b d $\sqrt{2}$.

Therefore .7 W = 12,000 p b d $\sqrt{2}$ + 50 b d $\sqrt{2}$ (1 − p).

$$\text{Whence } b\,d = \frac{.7\,W}{12{,}000p\sqrt{2} + 50\sqrt{2}\,(1-p)} \quad (2)$$

Equating the two equations (1) and (2) and solving for the value of p, there results 0.0232, or practically the percentage of vertical reinforcement in a column to resist compression and shear should be 2½.

The writer confesses to ignorance of any rational method of obtaining the bulging or swelling force at the circumference, and hence to any rational means of proportioning the tie rod. On general principles, however, he would make the sectional area about 25% of that of one vertical rod, and this tie should be continuously wrapped in a spiral about the vertical rods so that one complete turn would be made in a distance not greater than the least side of the column.

When it becomes necessary to splice the vertical rods, they should lap a distance equal to 40 times their side or diameter, on the assumption that the safe bond or adhesive value is 50 lbs. per sq. in. of surface of embedded metal, and the unit compressive stress is 7,500 lbs.

As a general rule the length of column should not exceed 12 times the least side, but should it be necessary to consider bending or transverse stresses, it will be found that the 2½% of vertical reinforcement, as determined above, has already provided 1¼% on any side which may happen to be placed in tension due to the bending, and this amount of reinforcing is generally conceded to be nearly sufficient to develop the full strength of the concrete in compression.

$$\text{With } p = 2\tfrac{1}{2}\% \text{ formula (1) becomes, } b\,d = \frac{W}{675}. \quad (3)$$

To conclude: Let it be required to design a reinforced concrete column to carry a vertically imposed load of 32,000 lbs.

$$\text{From formula (3), } b\,d = \frac{32{,}000}{675} = 47.4 \text{ sq. ins., say } 6 \times 8 \text{ ins.}$$

The area of steel = 0.025 × 48 = 1.20 sq. ins., say four ⅝-in. round rods or four $^9/_{16}$-in. square bars.

Sectional area of tie rod = 0.25 × $^9/_{16}$ × $^9/_{16}$ = say a round rod $^9/_{16}$-in. in diameter, which should be continuously wrapped about the four vertical rods, making one complete turn in every 6 ins.

Very truly yours, Engineer.

Toronto, Ont., March 31, 1906.

Filing Methods for Engineers in Private Practice: Rolled Maps or Separate Sheets?

Sir: In reference to Mr. Emil Low's letter in your issue of March 5, 1906, as to the relative values of rolled maps and separate sheets, it seems to the writer that there is a legitimate place for both, and no system of filing will be complete without provision for both. Standard sizes should be adopted, and all drawings within the limits of the largest size made to conform to one of them, and these drawings all filed flat in drawers to fit, each size in its own drawer; a great deal, too, may be sacrificed, and time and effort spent, to bring as many drawings as possible within the prescribed limits, but for such maps as those necessary for a railroad location the writer believes there is too much lost by using the separate sheet method.

He is firmly convinced that whatever may be thought theoretically true, in actual practice the quality of the location is bound to suffer by the use of separate sheets. The day of the so-called "genius" (if he ever existed) who could go out and throw his line, curves and all, at a hill, and have it settle just in the right place, just as a cowboy drops his rope over the horns of a steer, is gone, and the man who makes the successful location to-day is he, who, after he has studied his country, studies his map and works back and forth on various projected lines, until he is thoroughly steeped and soaked in the details of the country.

With his map on a roll he gets a comprehensive view of the whole situation, and he rolls it back and forth with no effort and with nothing to detract his attention from the study of the situation. With the separate sheet method, there are numerous small annoyances connected with its use in camp. The chances are that half the time when the sheets are needed some will be in the field, getting the topography on perhaps some side line that has been run. In running side lines, too, these are quite liable to come along the edge of a sheet, with perhaps the topography on one side of the line on one sheet and on the other side on another, which adds greatly to the cost of the topography, as well as introducing chances of error.

In arranging the sheets on the drawing table, after they have been in use any length of time, it is found that they do not fit well on account of unequal shrinkage or swelling of the paper. The mechanical difficulties of platting a long line on separate sheets, and having it always match right, especially where long tangents are to be projected, can only be appreciated by those who have tried both ways. Any one who has worked in camp knows the tendency of the wind to pick up and deposit any kind of loose sheets of paper in perhaps the only mud puddle within a mile. Separate sheets, too, introduce a mechanical difficulty, when stretching a thread over the map to locate the tangents, on account of the edges curling, even if the curling is very slight.

Aside from all these, which are after all only minor difficulties, the principal objection of the writer is that working on separate sheets, from the very fact that they are separate, and that therefore the map is broken up into several small parts, destroys that broad comprehensive view of the whole situation which is so essential to the determination of a proper location. As the locating engineer projects his location and works towards the edge of the table, he has to take up all the sheets, tack down and rematch part of them and some new ones, and then each time he wants to go back and review his work the same thing has to be repeated. The writer contends that even after the proper country for the line has been determined it is only by repeatedly projecting lines, getting their profiles and calculating their cost, that the best line the country affords can be determined, and the roll map offers inestimable advantages over the separate sheet methods in that it is more easily accessible for that broad comprehensive view and review of the whole situation that is absolutely necessary for a proper location.

The advantage (and really the only one worth considering) which is claimed for the separate sheets on railroad location is, that they may be taken into the field and the topography platted directly on them. The writer believes, in fact knows from actual experience, and for reasons given elsewhere, that topography can be taken in the field, and afterwards transferred to the roll map in the office tent at less expense, provided proper methods are used.

Where the subject of the drawing is such that it can be shown wholly on one sheet, or can be shown in separate parts on a series of sheets, the standard size, flat filing method is preferable, but for maps and profiles where it is necessary to show a long continuous stretch, rolls are necessary and adequate provision must be made for properly filing them.

Yours very truly,
F. Lavis, Assoc. M. Am. Soc. C. E.

P. O. Station No. 1, Hoboken, N. J., April 13, 1906.

Notes and Queries.

J. M. S., St. Louis, Mo., writes:

I notice on plans sent out by different railroad companies, that one company will designate the section through the length of a barrel of a culvert as the longitudinal section, and that another company will designate the section through the arch and parallel to the center line of the track as the longitudinal section. Will you kindly advise which is the correct expression to be used in designating longitudinal sections.

A longitudinal section is a section taken parallel with the length of a structure, so the longitudinal section of a long culvert under a high embankment would naturally be taken along the axis of the culvert. On the other hand, if the structure were a long span arch of say 100 ft. span and 15 ft. width, the longitudinal section would naturally be taken by a vertical plane passing through the two abutments. Similarly a cross-section of a railway tunnel or a bridge span is taken transverse to the track but a cross section of a sewer running underneath the track or of a long culvert would be taken by a plane parallel with the track. It will be clear that where a culvert has a length equal to its span, a longitudinal section may mean a section in either direction.

Our attention has been called to some errors in an equation in the letters from F. W. Hanna, on "Depth of Thread of Mean Velocity in Rivers," in our issues of Jan. 11 and April 12, 1906. In the equation

$$y = a\,d \pm d\sqrt{\tfrac{1}{3}\,(a^3 + b^3)},$$

the plus and minus sign was printed as the sign of equality in the former issue and was omitted entirely in the latter. Perhaps we may be pardoned for saying that proof of each letter was submitted to the author before publication.

WATER SUPPLY, FIRE PROTECTION AND CONFLAGRATION HAZARD AT SAN FRANCISCO, CAL.

The natural desire of engineers and other scientists to study the effects of the earthquake and fire which occurred at San Francisco last week leads us to put on record an outline of some of the conditions prevailing in that city at the time of the disaster. These will relate chiefly to the water supply and fire protection systems and to the character of the conflagration hazard. For the information presented we are chiefly indebted to a report on San Francisco dated October, 1905, made by the National Board of Fire Underwriters' Committee of Twenty.*

Before passing to our abstract of the report, attention may be called to a few features of commanding interest in the San Francisco conditions, as related or possibly related to the events of last week: Two of the highest earth dams, and one of the highest and largest, if not the most important, concrete dam, in the world, form a part of the works of the Spring Valley Water Co.; there are also a number of interesting supply conduits connected with the works, including wrought iron pipe, timber flumes and masonry conduits; 90% of the buildings in the city were of wood, and nearly all the buildings of other materials were of brick, with wooden floor joists. There were a number of large and a few tall buildings with steel frames and masonry shells, but only a small percentage of all the buildings in the city were of fireproof construction; nearly all the buildings other than wood were in the district most affected by the earthquake, which district included the congested and greatest conflagration hazard district; the city had an extremely varied topography, but throughout a large section there were few parks or other breaks in the built-up area.

In view of the reports placing the earthquake and fire losses at $200,000,000 and upwards, it is interesting to note that the total assessed valuation for purposes of taxation in 1904 was $503,000,000, of which $380,000,000 was on real estate and $123,000,000 on personal property. The population of San Francisco increased from 299,000 in 1890 to 343,000 in 1900, and the estimated population is now 400,000.

The total area of the city, to the established water front, was 47.94 sq. mi. A large portion of this area, however, was unreclaimed land, and much of the latter was shifting sand, leaving the occupied portion of the city only 20.9 sq. mi. in area. The fire limits embraced only 1.6 sq. mi., and the so-called "brick-built district" had an area of only 0.95 sq. mi. The area of the congested value district was 0.49 sq. mi.

As is well known, San Francisco occupies the northern end of a peninsula which is [illegible] from the mainland at Oakland by a [illegible] five miles in width. The southern boundary is about seven miles from the Golden Gate on the extreme north. The elevation of the city ranges from some 20 to 900 ft. above sea level. Several hills rise to elevations of 350 to 400 ft., and the uppermost occupied portions of the western slopes of Twin Peaks reach elevations of more than 550 ft. Many of the streets are of heavy grade, the extremes running to from 30% to 39%. In the principal mercantile and manufacturing sections, however, the grades do not exceed 5%. In the congested value district in the old part of the city to the south of that district, many of the streets are narrow.

WATER SUPPLY.—The water-works of San Francisco are owned and operated by the Spring Valley Water Co., with the exception that the fire hydrants belong to (and are maintained by?) the city.

The water supply is mainly from drainage areas to the south. It is conveyed from impounding reservoirs and infiltration works by means of three main supply conduits leading to as many main distributing reservoirs in the city. The distribution system includes the unusual feature of five services, corresponding to differences in elevation of some 500 ft. Of these the report states:

> The three lower services, covering the more important parts of the city, including practically all of the mercantile and manufacturing section, are supplied by gravity flow from distributing reservoirs within the city limits; the two higher services, of residence occupancy, by pumpage from distributing mains of the lower services with some reserve storage in equalizing tanks.

The general location of the sources of supply, impounding and distributing reservoirs and supply mains connecting the two classes of reservoirs are shown on the accompanying map, which is reproduced from the report of the committee. To the right of the upper part of the map will be found condensed information regarding the main supply conduits and the reservoirs.

The Pilarcitos and the San Andreas dams are each of earth, 95 and 93 ft. high, respectively, above the original surface of the ground, and with puddle walls carried 40 and 46 ft., respectively, to rock. The Crystal Springs, or San Mateo, dam (see Eng. News, March 2, 1889), is a heavy concrete dam, of arched type, 115 ft. high above the natural surface, and 146 ft. from rock foundation to crest. It is composed of enormous concrete blocks, built in place, and well bonded by offsets.

The Lake Merced drainage area, which is partly within the city limits, consists of a succession of sand dunes overlying impervious strata. Lake Merced is a natural body of water which has been used for water supply since 1877. A 23-in. force main 9,000 ft. long, leads from it to the Pilarcitos conduit.

The various supply systems are connected by a number of branch conduits which include wooden flumes and wrought iron pipe.

The total storage capacity for the five supply systems outlined above is about 28,360,000,000 gals. The available daily supply from the drainage areas as now developed is placed at 35,000,000 gals., of which 18,000,000 is from Pilarcitos, San Andreas and Crystal Springs sources, 14,000,000 from Alameda Creek sources, and 3,000,000 from Lake Merced.

The various supply conduits are said to be in good condition, especially the riveted wrought-iron pipes, "the extensive use of which for water conveyance was inaugurated in this city, and their good condition after 35 years of continuous service testifies to superior quality and workmanship." The flumes and pipes are patrolled daily, and materials for repairing the flumes "are stored at a centrally located point on the watershed, and repairs can quickly be made."

The Lake Honda reservoir is formed in a natural basin, with the slopes on two of its sides lined with concrete. The Lombard St. reservoir is in rock excavation, has its slopes puddled and then paved with brick. The Potrero Heights reservoir was excavated in hardpan and had its bottom and sides puddled. The largest of the three iron water tanks within the city, that at

*Mr. S. H. Lockett, of 135 William St., New York City, is secretary of the committee; Mr. F. F. Moore is hydraulic engineer and Mr. S. A. Reed consulting engineer. The report was compiled mainly from data collected in May, June and July, 1906, by an engineering force headed by Messrs. R. C. Clark, A. H. Smith and R. C. Martin, who had charge, respectively, of structural, hydraulic and fire department work.

Presidio Heights, is 60 ft. in diameter, 35 ft. deep, and rests on a concrete foundation.

Altogether there are eight pumping stations connected with the works, with pumps of from 8,000,000 to 1,500,000 gals. capacity. Most of the pumps are small. Underground concrete reservoirs are used to store fuel oil at a number of these stations.

Out of the 419 miles comprising the whole distribution system, about 12 miles were of wrought-iron. Of the 407 miles of cast-iron pipe, 35% was more than 30 years old, and 28% was less than 10 years old. Of the wrought iron pipe, 9,100 ft. of 22-in. was laid in 1870, and a considerable part of the remainder was laid as long ago as 1885.

The principal street foreman stated that in the congested value district the valves were so spaced that the average length of pipe cut out by a break would not be more than 1,000 ft., but the representatives of the Committee found a place where a single break would cut out 3,900 ft. of pipe and 21 hydrants. In the residence district a place was found where a single break would cut out 9,600 ft. of pipe and 23 hydrants. [These conditions seem to have been exceptional.]

In the older part of the city, 23 fire cisterns, of from 16,000 to 100,000 gals. capacity, are located. Salt water for 28 hydrants was provided by the Olympic Salt Water Co., which was organized to supply a number of bath houses. The pumping station was located at the foot of Avenue B, on the Pacific Ocean, and was connected by a long 16-in. force main on Point Lobos Ave. with the reservoir between Josephine and Eugenia Sts. From this reservoir a 12-in. main led to Van Ness St., and there subdivided into 12- and 6-in. branches.

A separate fire main system was under consideration when the report was written, and $150,000 had been appropriated for a reservoir site and other initial work. A 20,000,000-gallon reservoir on the north side of Twin Peaks, near an extension of 20th and Stanyon Sts., was proposed. The reservoir would be at an elevation of about 775 ft. and would develop more than 300 lbs. pressure in the congested value district. A 700,000-gal. relief tank, near 17th and Ashbury Sts., at an elevation of about 450 ft., would give an ordinary pressure of from 100 to 190 lbs. in the mains. Employees stationed at the tank would turn on the full high pressure when a fire alarm was received. No plans for the distribution system had been made, further than that a 22-in. main was proposed from the reservoir along 17th and Market Sts. to the congested value district. For supplying the reservoir, salt water from either the bay or the ocean, or fresh water from the Spring Valley Water Co.'s system, were under discussion, with the balance of opinion in favor of salt water. [It is interesting to note that Fire Chief Sullivan, who died several days after the earthquake from injuries received at that time and who did not know that a conflagration was raging, spoke several times between his injuries and death of the importance of establishing a salt-water fire system.]

In concluding its description of the water supply system, the report of the Committee of Twenty stated:

> In general it may be said that the company has exhibited commendable vigilance in maintaining the reliability of supply.

It was recommended that additional storage should be provided for the Telegraph Hill section. It was stated that the average pressure of 52 lbs. found in the congested value district was too low for good fire protection. Reinforcement of feeding and distributing mains, additional gate valves, an improved type of hydrants, and the installation of a separate fire main system, were recommended.

FIRE DEPARTMENT.—This department has been on full-pay basis since 1900. It is described in the report as "an efficient force," well organized and fairly equipped, except for weakness in powerful engines. Of fire engines there were 38 in service and a considerable number in reserve. Tests of eight of the engines, in June and July, 1905, showed an average discharge of less than 70% of their rated capacity, pumps in fair or good condition, steaming capacity of boilers low, and general ability of the men in handling the engines "below a proper standard."

No fire boats were maintained by the fire department, but the State Board of Harbor Commissions had two tugs in use (for dredging), equipped with fire pumps and available for service when within sound of a fire alarm whistle. Each boat had two pumps, one of 950 and the other of 850 gals. per min. capacity, against 150 lbs. water pressure when operating separately; but when operated simultaneously, the combined discharge of the pumps on one boat was 1,400 and on the other

SUMMARIZED DESCRIPTION OF MAIN SUPPLY CONDUITS, FROM HEAD TO CITY.

Pilarcitos Conduit:

Material.	Size, ins.	Length, ft.
Brick-lined tunnel	42 × 54	1,550
Wooden flume	36 × 60	280
Brick-lined tunnel	42 × 54	3,420
Wrought-iron pipe	44	750
Wooden flume	36 × 60	2,147
Cast-iron pipe	24	776
Wrought-iron pipe	22	2,394
Wrought-iron pipe	30	64,000
Wooden flume	16 × 42	5,240
Wrought-iron pipe	30	940
Brick-lined tunnel	36 × 52	2,820
Total	(15.98 miles)	84,317

Capacity: Gravity, 5,000,000 gals. per day; by pumping at Pilarcitos station, 11,000,000 gals.; by pumping at Lake Merced station, 17,000,000 gals. Built in 1870.

San Andreas Conduit:

Material.	Size, ins.	Length, ft.
Brick-lined tunnel	42 × 54	2,820
Wrought-iron pipe	44	28,849
Wrought-iron pipe	37	1,400
Wrought-iron pipe	30	40,185
Total	(13.88 miles)	73,254

Estimated capacity: Gravity, 11,000,000 gals.; when reinforced by Crystal Springs water from the pumping station at Millbrae, 13,000,000 gals. Built in 1870; the 40 and 37-in. pipe was substituted for 30-in. in 1900.

Crystal Springs Conduit:

Material.	Size, ins.	Length, ft.
Wrought-iron pipe	44	88,000
Brick-lined tunnel	4½ × 4⅝	2,000

Lengths are approximate; tunnel near lower end. From Burlingame to Millbrae, paralleled by 16,758 ft. of 54-in. wrought-iron pipe, laid in 1903, not shown on map. Carrying capacity, with full storage reservoir, 24,000,000 gals. a day; diminished to 18,000,000 gals. when Millbrae pumps force water from this conduit to Alameda conduit.

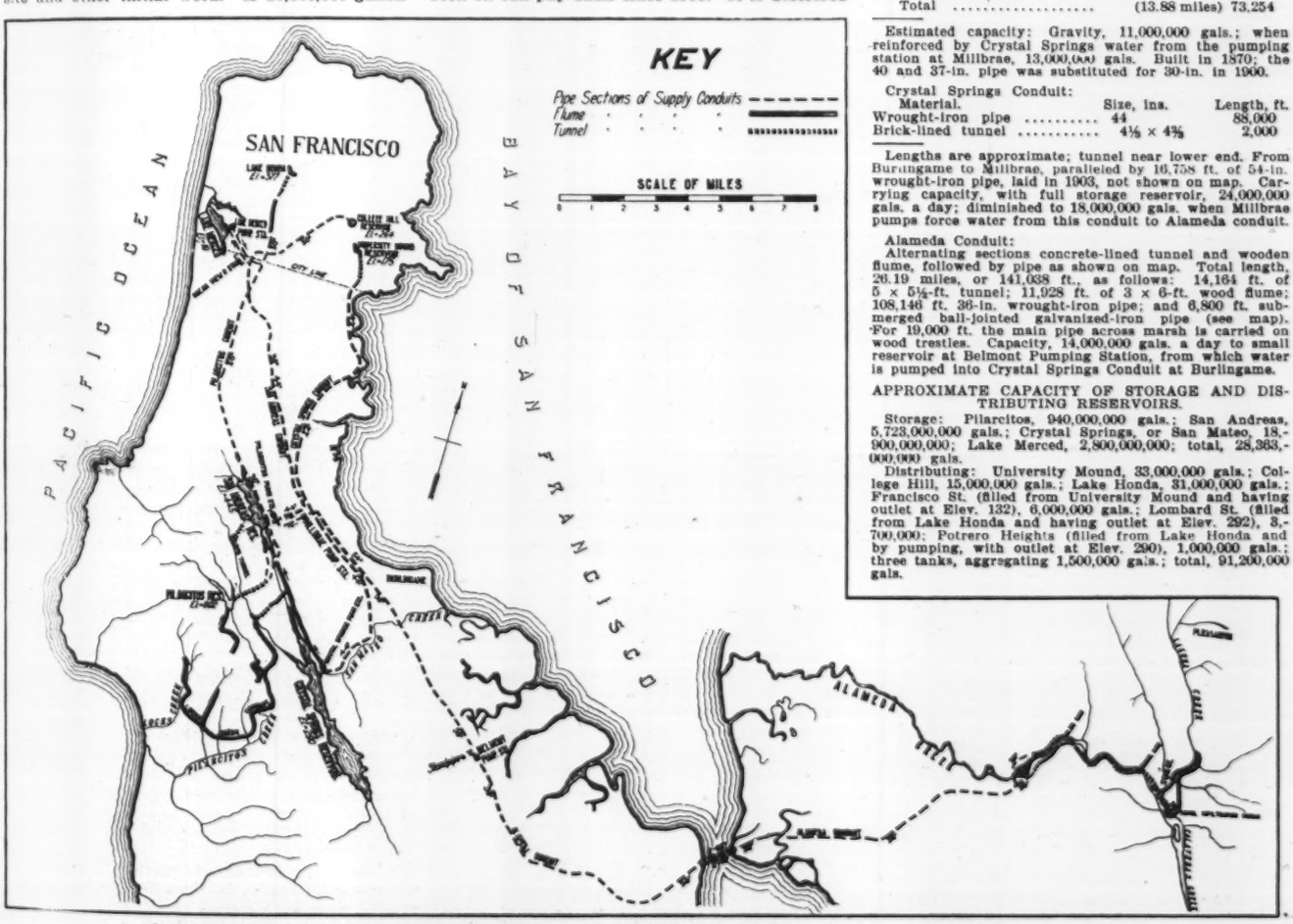
Alameda Conduit:

Alternating sections concrete-lined tunnel and wooden flume, followed by pipe as shown on map. Total length, 26.19 miles, or 141,038 ft., as follows: 14,164 ft. of 5 × 5½-ft. tunnel; 11,928 ft. of 3 × 6-ft. wood flume; 108,146 ft. 36-in. wrought-iron pipe; and 6,800 ft. submerged ball-jointed galvanized-iron pipe (see map). For 19,000 ft. the main pipe across marsh is carried on wood trestles. Capacity, 14,000,000 gals. a day to small reservoir at Belmont Pumping Station, from which water is pumped into Crystal Springs Conduit at Burlingame.

APPROXIMATE CAPACITY OF STORAGE AND DISTRIBUTING RESERVOIRS.

Storage: Pilarcitos, 940,000,000 gals.; San Andreas, 5,723,000,000 gals.; Crystal Springs, or San Mateo, 18,900,000,000; Lake Merced, 2,800,000,000; total, 28,363,000,000 gals.

Distributing: University Mound, 33,000,000 gals.; College Hill, 15,000,000 gals.; Lake Honda, 31,000,000 gals.; Francisco St. (filled from University Mound and having outlet at Elev. 132), 6,000,000 gals.; Lombard St. (filled from Lake Honda and having outlet at Elev. 292), 5,700,000; Potrero Heights (filled from Lake Honda and by pumping, with outlet at Elev. 290), 1,000,000 gals.; three tanks, aggregating 1,500,000 gals.; total, 91,200,000 gals.



GENERAL MAP OF THE WATER SUPPLY WORKS OF THE SPRING VALLEY WATER CO., SAN FRANCISCO, CAL.
(From Report of the National Board of Fire Underwriters.)

930 gals. per min., owing to insufficient steam supply.

STRUCTURAL CONDITIONS AND HAZARDS.—The building code passed or revised since 1900 "is quite extensive and covers fairly well all classes of buildings except reinforced concrete work and mill construction." No protection is required for openings in fireproof buildings, but tin-clad or steel rolling shutters or wire glass in metal frames are required for all openings in any building exposed within 30 ft. in non-fireproof brick or stone buildings more than two stories high, occupied as stores, storehouses, mills, or manufactories.

An inspection of the congested value district showed that it consisted of 101 blocks and 2,086 buildings. Of the buildings 2.2% were fireproof, 68.3 were joisted brick, and 29.5% were of frame construction. The largest fireproof structures were a twelve-story office building, with an area of 28,000 sq. ft., a 12½-story hotel having an area of 21,600 sq. ft., and a 19-story office building of medium area. The building of largest area in the business section ranged in height from two to seven stories, was of fireproof construction to the fourth story and slow-burning above, and had an area of 88,400 sq. ft. It was occupied as a department store below and with offices above. Of the brick and joisted construction in the congested district, one was a seven-story hotel with an area of about 84,000 sq. ft. No less than 13 buildings, all without fire sprinklers, had areas exceeding 20,000 sq. ft. There were several non-fireproof buildings eight stories in height. Two frame buildings had areas of 18,900 sq. ft. and 18,400 sq. ft., the first being a four-story lodging-house and concert hall and the second a store below and hotel above. In the whole congested value district, "there is but one sprinkler equipment and it is practically obsolete." Some 120 buildings contained stand-pipes and hose, and a few small fire pumps drawing from deep wells. Wire glass windows were but little used. Two sentences, slightly separated, may be quoted:

Slight earthquake shocks are not uncommon, but their effect on walls is not noticeable and reported to be of little consequence.

About 90% of the entire city and 30% of the business section is of frame construction, brick buildings being confined almost entirely to the fire limits, and San Francisco can be justly termed a "wooden city."

The general conclusions of this section of the report may be briefly summarized, as follows:

"Bad exposures, poor construction, lack of proper protective devices, excessive height in non-fireproof buildings, large floor areas, and a large percentage of frame construction," are the principal features affecting the conflagration hazards in the business district. The worst class of buildings should gradually be replaced and the others should be protected in the most effective manner. The installation of sprinkler equipments should be enforced. The character of the building construction outside the fire limits and immediately surrounding the congested value district affords very serious exposure to that district. The security thought by some to be afforded by redwood construction and by the dampness existing at San Francisco "is regarded by the National Board of Engineers as fanciful merely."

In the final summary of the whole report, under potential conflagration hazards, it is stated that the probability feature is alarmingly severe, owing to the absence of sprinklers and fire protective devices generally, the numerous conflagration breeders, the high winds and the comparatively narrow street. Finally, the summary states

not only is the hazard extreme within the congested value district, but it is augmented by the presence of a compact surrounding great-height, large-area, frame-residence district, itself unmanageable from a fire-fighting standpoint by reason of adverse conditions introduced by the topography. In fact, San Francisco has violated all underwriting traditions and precedent by not burning up. That it has not done so is largely due to the vigilance of the fire department, which cannot be relied upon indefinitely to stave off the inevitable.

FIREPROOF TRIM or interior finish for buildings has recently been invented, in which a casing of thin sheet metal is used, filled with concrete. This can be used for door jambs, casings, baseboards, picture moldings, etc., and becomes a part of the structure. The parts are built at the factory, and the door and window frames, etc., may be set in place before the walls are built, as in the case of wooden frames. This is the invention of Mr. W. D. Mann, 353 Grand Central Station, Chicago.

FIRE-RESISTING CONSTRUCTION AND THE ULTIMATE LIFE OF MERCANTILE BUILDINGS: A PLEA FOR BETTER CONSTRUCTIVE METHODS.

By J. K. Freitag,* Assoc. M. Am. Soc. C. E.

The paper which Mr. Reuben A. Denell, of the Waring-White Building Co., Ltd., of London, recently read before the British Society of Architects† contains much food for serious thought on the part of those intimately acquainted with present American practice in building construction—particularly permanent or fire-resistive construction as applied to public, semi-public and all classes of mercantile buildings. Formerly connected with D. H. Burnham & Co., architects, of Chicago, Mr. Denell has lately been associated with the above-mentioned English construction company. In particular he has been connected with the Ritz Hotel, recently completed in London after the American steel-frame method. Owing to his large experience in this character of work, Mr. Denell very suitably took advantage of the opportunity to inform his English brother architects as to the great advantages of steel construction or skeleton construction from the standpoints of commercialism, rapidity of construction and economy of erection.

The most interesting and the most significant points brought out in the later discussion of the paper by the English architects present were their inherent distaste to the idea of adopting purely skeleton methods, or to the introduction of many-storied "sky-scrapers," as termed in this country; but above all was exception taken to the "rush" of building operations as carried on with us, thereby preventing, from the more conservative English view, that thorough and systematic inspection and supervision, that careful deliberation, that opportunity to make changes or improvements in plan or construction as the building progresses, all of which have ever been considered the prerogative of the English architect.

With the English deprecation of inordinately high buildings, every thinking American must largely sympathize when the question is separated from the purely commercial aspect. With their prejudice against steel skeleton methods, per se, we have little or no sympathy, nor are we likely to have, even as a possible revulsion from present building methods. The principle is too deeply ingrained in our architectural tastes and requirements and the factors which brought forth these methods will long remain too potent to be easily overthrown.

But in the English or Continental aversion to or criticism of our American hustle and hurry, our ofttimes unwarranted haste and consequent carelessness, our lack of consistent thoroughness in fire-resistive construction, our neglect of careful and searching supervision or inspection by the architect or engineer, and our building operations in a race "against time," whereby the date of completion to insure some advantageous leases or rents is of more importance than thoroughness or the pssibility of improving the work through corrections or changes as the work progresses—in all of these criticisms much truth and argument must be admitted by those who seriously stop to consider where present "rush" tendencies are leading us.

A strictly truthful answer, regardless of how it may affect our national pride, our business interests or our pocketbook, must require the admission that present building methods are largely decidedly faulty in that thoroughness, supervision, adequacy and permanence which should properly be looked for in those buildings of great cost which now form so large a proportion of our building operations in large cities. This is particularly true of buildings intended to be of fire-resistive construction, partly because this class of buildings now embraces the more prominent structures of all uses, and also partly because in the supposedly fire-resisting features of these buildings are found many of the most glaring examples of that haste, carelessness and inadequacy which are so to be deplored.

There is no question but that many buildings are constructed with efficient care as [illegible]wards permanence against sudden fire or slow [illegible]sure corrosion or deterioration. The permanency and wisdom of steel-skeleton building method[illegible] not here questioned in the least. There is ample testimony to show that steel buildings can [illegible] are being made safe and permanent for any [illegible]th of life which may reasonably be expected [illegible]them, especially where care and a sufficient [illegible]t of time are combined with proper mate[illegible] and adequate supervision. But, unfortunat[illegible] there are other examples, only too numerous, [illegible]rein early depreciation or deterioration an[illegible]nger from severe or total fire-loss are only t[illegible]mmi-nent; also other examples in which the [illegible] are rather those of commission than omi[illegible] of "snide" or slighted work, which can b[illegible]rmed nothing but dishonesty pure and simple[illegible]surely "graft" as the "job" of the unscrupu[illegible] politician.

Neither is this any tirade against [illegible]ncrete, terra cotta tile, or any other particular [illegible]truction. But it is honesty, efficiency and pe[illegible]nence in building work that are here being co[illegible]dered; and in these qualities it is often the mos[illegible]retentious buildings which are the chief offe[illegible]s.

If, perchance, these views are thought to [illegible] those of an alarmist, consider for a few mo[illegible]s the striking testimony as to honesty, efficiency and permanence brought out in the Baltimore conflagration! Regarding honesty, remember the large areas of exterior masonry walls in one of the more prominent burned "fireproof" buildings where the work consisted of outer and inner one-brick walls, filled in with loose and largely uncemented brick-bats, broken tile and almost any refuse.

As to efficiency or permanence, to take only those features of fire-resistive construction which should have been fully as well understood before the Baltimore fire as after, consider the partition construction and column protections, with their almost utter failure of a most excellent material used without intelligence; the totally inadequate floor arches used in the Equitable building; and the complete failure of various cheap plaster-block and substitute constructions, introduced under false ideas of economy and efficiency.

Few of those thoroughly acquainted with present day building operations will find it difficult to recall instances illustrating either skimped or grossly careless building work.

As an example of the latter, may be instanced an many-storied bank and office building, completed within the year past in one of our large cities, in which absolutely no brick-backing or fireproofing of any nature was provided between the granite facings of the lower story piers (running through the banking floors) and the steel columns within those piers. The streets bounding the building are not wider than the average, and many highly combustible buildings surround the structure. And yet, after the emphatic warning against such construction furnished by the Baltimore fire, the structure is proclaimed far and wide "a signal addition to the bulwarks of fire resistance," in spite of the wreck and ruin which might result at any time from a severe fire in a neighboring building. And this is the policy, the conservatism, exercised by a bank of national repute, which would doubtless be greatly astonished if informed that its building committee was speculating to a very dangerous degree on immunity from fire.

The causes for these ofttimes deplorable conditions of carelessness, haste and inefficiency are to be found partly with the owners or investors, partly with the architect or engineer, sometimes with the contractor, and also frequently in the laxness of our building regulations.

Considering first the influence of owners or investors upon such questions, it is to be feared that examples of frenzied building finance are responsible for many ills. One of the most prominent types of building construction now prosecuted in this country is the city office building, ranging from five or six stories in height to twenty stories or more. In some cases, at least, it is a pertinent question to ask what moral responsibility for the finished product is assumed by the original owners, those who finance the

*166 Devonshire St., Boston, Mass. Author of "Structural Engineering"; "The Fireproofing of Steel Buildings."

†See Engineering News, March 1, 1906.

building scheme for a quick turning over of the property to others at a profit—and an equally pertinent question as to the seemingly short-sighted policy of many of those who build for a permanent investment?

Buildings represent capital. The employment of capital constitutes an investment. The average investor will consider long and carefully the purchase of a valuable piece of real estate, yet when he comes to improve that real estate by a building scheme or investment costing possibly twice as much as the land value, the safe, lasting genuine qualities of the structure are considered of far less importance than the exterior attractiveness or the economy of planning.

In speculative building, of which a very large amount has been done during the past few years, what thoughts of permanency, thoroughness or efficiency against quick deterioration, or what safety against possibly quicker destruction by fire have entered into the value of the property to be turned over to others—possibly small investors in the shares of building trusts, who have no means of knowing that the job has been rushed and skimped, but who only see the veneer of newness and apparent excellence? Fortunately this is not true of all speculative building, but it is of some. The writer carefully watched the building of a recent example. Owing to haste, carelessness and general indifference, the first winter, after the original owners had "sold out," found tenants freezing from an inadequate heating plant combined with poor construction, while within a year not a door in the building closed tightly. Fortunately, fire has not added to the already severe burdens. What unjust loads of repair, renewal and even total loss may not fall upon holders of just such "false pretence" property?

As to those who build carelessly for permanent investment, what wrongs of omission and commission may not the children coming after have to reckon with in connection with that property which may represent their all in all?

In other words, do the original owners of many of our largest and most expensive buildings build for their own lifetime only, or with any consideration whatever for the moral duty they owe to the community, or for those elements of permanency and efficiency which those coming after them have a right to expect?

The usual deficiencies contributed by the owner to building construction comprise, first, haste, in grudging the tying up of the capital represented by the building for a sufficient length of time to permit of careful, conscientious work. A good building, like anything else, requires a certain time to construct. Modern "rush" tendencies, to get the building done by a certain date regardless of workmanship, are pernicious in the extreme. The owner requiring such a contract deliberately invites slighted work on the part of the contractor, and slighted supervision on the part of the architect. Mechanics can perform honest work for not over nine or ten hours a day. Beyond that limit the work is sure to be slighted. Night gangs can never equal day gangs in excellence of work done. The architect, under the press of a time contract, will accept or pass mediocre or poor work, rather than take the responsibility of delaying the completion, and this knowledge is not infrequently taken advantage of by the unscrupulous contractor.

Second, is the indifference of the average owner to adequate fire resistance, or the willingness to shift the burden of fire loss upon the community in the shape of fire insurance. Even if an owner cannot see the value of fire safety to his own investment, his moral duty to erect a unit of fire resistance contributing to the safety of his neighbors and the community is becoming more and more recognized. But nine out of ten so-called "fireproof" buildings fall far short of what they could and should be. Surely, if fireproofing is worth undertaking at all, it is worth doing well. Yet the comparatively slight difference in expense between adequate, effective fireproofing and half-way methods of proven inefficiency is considered either needless extravagance or foolish precaution. Prevalent terra cotta partition construction constitutes perhaps the most flagrant example of inefficiency. Often built on wood flooring or screeds, usually of inadequate thickness, of too large blocks, and seldom properly wedged to give the stiffness requisite to withstand hose streams, is it any wonder that the record is as poor as it is, to say nothing of the utter foolishness of introducing wooden rough frames for door openings, and wooden sash and frames for top-lights? The added expense of thoroughly reliable terra cotta partitions, correcting all of these errors and weaknesses, would be but a trifling percentage of the cost of the entire building, and yet possibly be the means of saving the entire building, or at least its contents, in a crisis.

The architect—that is, the average architect, for there are notable exceptions—contributes to inefficient building methods through lack of knowledge regarding constructive principles, lack of care and often interest in vital details of fire-resistive planning or details of contruction, and lack of rigid, intelligent inspection of materials and workmanship, particularly the latter. For examples, take the instance of hollow masonry walls filled with rubbish, the existence of which were disclosed in the Baltimore fire; the prevalent column covering exhibited in that same fire; the cutting away of the lower surfaces of terra cotta arch blocks to save the expense or trouble of cutting down marble ceiling and wall finish which had been gotten out too large. For the inspection given terra cotta arch construction, witness the Park Row Building.* For poor workmanship in concrete construction, witness the beam protection afforded in the Butterick Building. Examples need not be multiplied. There is ample room for improvement, both in the matter of more fully detailing important elements of the work, insisting upon more mass or adequacy of material to prevent fire destruction or the ravages of deterioration, more complete and intelligent specifications, and in the rigid enforcement of all by painstaking inspection.

The contractor, between the devil of competition and the deep sea of no work, is obliged to take work on a time basis which he knows is incompatible with best results, thereby assenting to a wilful slighting of the character of the work. While those builders who are making records for mushroom growth building operations may be contributing to our national reputation for "hustle," they are certainly contributing little to the true and lasting qualities of the building methods of the "old-school" contractors of two or three generations ago.

In the report of the National Fire Protection Association on the Baltimore conflagration, the crying need of less haste and more care in building operations is emphasized as follows:

> Municipal building laws and inspection should enforce good construction in all details. Inspection of fire-resistive buildings in course of erection should be more frequent than is necessary for buildings of ordinary construction. One of the most discouraging features brought out by this fire is the wholesale evidence of lack of care and gross neglect in the execution of the work. This was evidenced in many ways, such as chopping away a portion of the floor arches for the purpose of applying ceiling finish; the breaking of tile column coverings for pipes and wires; the loose setting of tile partitions; the laying of curtain walls without sufficient mortar, and the poor fastenings of the fire-protective coverings for the lower flanges of beams and girders by the use of plaster, metal clips and even wooden strips.

Well would it be, then, for the future safety and integrity of our buildings if haste and carelessness could give way to the care and deliberation of our critics. It may tickle our national pride to compare our elaborate concrete mixing machines and our elevator hoists, etc., with the carrying of bags of cement, sand and crushed stone up tedious ladders to a crude plank mixing bed at an upper floor, as was witnessed by the writer not long since in Paris; but the fire record of England and the Continent tells the story of efficiency in building construction and fire resistance at least. According to the reports submitted by the U. S. consuls to the State Department at Washington, giving the fire and building regulations in foreign countries in reply to questions suggested by the National Board of Fire Underwriters, there is little doubt as to the superiority and efficiency of English and European construction.

Thus in London, in 1889, of a total of 2,892 fires, all but six were confined to the building in which they originated. "Legislation as far back as 1666 has encouraged or enforced the use of brick or stone in repair and emplacement, with the result that few, if any, timber structures now survive."

In Glasgow all but 14 fires in a total of 504 were confined to the floors where they started, while in Leeds, Sheffield, Bristol and Newcastle, England, every fire was confined to the building in which it originated, as was also the case at Antwerp, Havre, Brussels, Trieste, Copenhagen, Rome, Florence and Turin, in spite of many most ridiculous fire-fighting facilities.

In Hamburg, 682 fires occurred in 1890, 659 of which were confined to the original floor, 13 were confined to the building, while 10 only extended to an adjoining building. In Vienna it was reported:

> There is no case known in this city where a conflagration has extended beyond the building in which it originated, and even hardly any cases are known where a fire extended beyond the floor on which it originated. This is prevented by the solidity of the buildings, by strict fire regulations, and by a pretty well-trained fire department, ...

the latter consisting of "five steam engines, but very seldom called into action, and a large and sufficient number of hand engines," manned by 265 men in the department. Hardly what we would term an efficient fire fighting organization.

Before the above article could be type-written, came the news of the terrible calamity which has befallen San Francisco. What sadder evidence could transpire to show the absolute necessity for better constructive and fire-resisting methods in our American cities? It is true that the primary cause of the disaster lay in the disturbances of the earth's surface, thereby wrecking large numbers of structures and the water mains, but had not fire, among the very large numbers of poorly constructed and non-fireproof buildings for which San Francisco was well noted among fire-resisting experts, followed upon the earthquake, the resultant loss would to-day probably be but a small percentage of the total ruin. Had the entire business portion of San Francisco been composed of thoroughly fireproof buildings, it is probable that these would have better withstood the shock of earthquake than did those more poorly constructed buildings which are reported to have fallen, thereby spreading fire to the balance. And it is interesting to note, in the earliest accounts at least, that many, if not all, of the thoroughly fireproof cage-construction buildings withstood safely the tremors of the earth, succumbing only to widespread conflagration, apparently directly attributable to less efficient construction. Thus the steel frame 19-story Spreckels Building is reported to have been practically unharmed from the earthquake, but to have been later gutted from the surrounding conflagration. The same is reported of the Mills Building, the pioneer among the steel frame structures of San Francisco, erected in 1890 with the utmost care and rigidity, to provide against just such a possible contingency. The writer worked out many of the steel details of this latter building under Mr. E. C. Shankland, the chief engineer, and well recalls the discussions in connection with that building as to the possible effects of heavy seismic disturbances. In later years the Japanese Government commissioned Mr. Shankland to design some important buildings for Japan to be of the American steel-frame type, so as to be as proof against earthquake damage as possible.

But even if fireproof buildings had not proved able to better withstand the structural strain put upon them, had the business portion of San Francisco been composed only of approved fire-resisting structures, then those which remained standing would at least have proven, by their very uniformity, bulwarks of resistance against the spread of fire from the ruins of those which did succumb, and a far different story would undoubtedly have been recorded.

WATER FROM SHALLOW WELLS is being given particular attention by several state boards of health of late. Of come 200 samples from different parts of Indiana, Prof. H. E. Barnard, Chemist for the Indiana State Board of Health, is reported as having pronounced 65% unfit for use because of local pollution. Somewhat similar reports are coming from other states.

*See Engineering News, April 14, 1898.

THE SAN FRANCISCO DISASTER: EARTHQUAKE AND FIRE RUIN IN THE BAY COUNTIES OF CALIFORNIA.

An earthquake of wide extent devastated the central part of the coastal strip of California on the early morning of Wednesday, April 18, 1906, killing about 500 persons in San Francisco and an equal number in other cities and towns and the country districts. Destructive seismic motions occurred throughout a region several hundred miles long, and 30 to 50 miles wide, from the Pacific Ocean to the watershed of the Sacramento and San Joaquin rivers. Fort Bragg, 120 miles north, and Monterey and Salinas, 100 miles south of San Francisco, are roughly the extreme points of this territory of greatest violence, as far as the present meager reports show. Lesser damage was done at many points outside of this zone. Within the region indicated, buildings were shaken, cracked and thrown down, railway lines were thrown out of line and level at numerous points, many wire lines were interrupted, and permanent displacements and fissuring of the ground surface were produced in many places. The city of San Francisco suffered by far the greatest total damage, but at least equal intensity of destruction appears at San Jose, Palo Alto and Santa Rosa, all three within 50 miles of San Francisco. The concentration of damage in a narrow coastal strip is best shown by the fact that Oakland and Berkeley, seven miles east across San Francisco Bay, were relatively little injured. The earthquake affected seismographs throughout the world; Tokio (Japan), Florence (Italy) and Washington, D. C. are among the observatories which report records of strong seismic vibration coincident with the California disturbance.

But the ruin from the terrestrial disturbance was multiplied a hundredfold by its immediate sequel, a mighty conflagration in San Francisco, which in three days laid waste half of the city's populated area, rendered homeless and destitute more than half the 400,000 people of the city, and created a situation of primitive chaos. Within a few moments after the first (and most violent) earthquake shock in San Francisco, fire broke out at a number of different points in the congested business and tenement districts of the city, and spread with great rapidity. In two hours an uncontrollable conflagration was in progress. Aided by the winds, by the peculiarly great "conflagration hazard" of San Francisco's down-town districts, and by the impossibility of opposing effective resistance (because of blocked streets and wrecked water distribution system), the fire advanced in all directions unchecked until Thursday night, forty hours after its beginning. Then, after the final and most desperate effort of the fire-fighters had failed, a turn of the wind to the normal west of the trades stopped the advance of the fire at the most dangerous point of the fire line. By Sunday, April 22, when the fire was finally extinguished, it had burned over a densely built up area of approximately seven square miles; it had destroyed the whole business district of the city, a large manufacturing section, the entire crowded tenement portion, and a large part of the remainder of the populated area.

The superposition of the two calamities created conditions of emergency and distress rarely witnessed in modern times outside of war periods. This is due in no part directly to the earthquake. It appears from the news reports that the results of the earthquake alone would not have interrupted or delayed communication or the ordinary progress of human intercourse more than monentarily; the entire damage would have been dealt with locally in the regular procedure of business life, with perhaps some amount of gratuitous aid from outside. But when the fire ruined San Francisco, the commercial metropolis of the State, the effect was radically different. A concentrated population of 400,000, enormously wealthy and active, was in a single day reduced to its last loaf and the open air, with a wrecked water system, and only a few hours' supply of water; and, moreover, for 60 hours this community was in helpless retreat before a great unchecked conflagration. The situation was saved only by a rigid military rule (established within three hours after the first shock of the earthquake and not yet relaxed); phenomenal exertion locally to restore tenable conditions; and unparalleled rapidity and fullness of aid on the part of the entire country. The latter is exhibited in the fact that by the fourth day after the earthquake from 50 to 100 trains filled with food and other necessities were on the way to San Francisco, Government supplies to the amount of $1,500,000 were en route, $2,500,000 had been appropriated by the Government, and over $10,000,000 had already been given throughout the country for immediate assistance. The first relief shipments from East and South arrived Saturday; for two days previous the city had been fed by prompt, unasked shipments of food supplies by wagon and rail from the immediately surrounding country, and from Portland, Los Angeles and other Coast points.

But if in the human interest of its result the San Francisco conflagration vastly overshadows the earthquake disaster, it is otherwise in engineering interest. The earthquake results will yield teachings of very great interest; the conflagration will teach but little. The fire is merely a repetition, unaltered in its main phases, of the great Baltimore fire of 1904. Its teachings are a confirmation and reinforcement of the Baltimore lessons—an appalling confirmation, it is true, and therefore perhaps the more effective as a reinforcing demonstration. It happens that the fire insurance interests, the National Board of Fire Underwriters, forecasted the conflagration quite definitely. During the year following the Baltimore fire they made "conflagration hazard" surveys of many important cities in the United States. Their exhaustive report on San Francisco closes with the statement that an unparalleled conflagration risk is presented by that city, and that the elements which in the past had averted a large fire "can not be relied upon indefinitely to stave off the inevitable." The actual realization of this extraordinary prediction brings no original information other than in details.

Some degree of comfort may be found in the remarkable circumstances attending the start of the conflagration: the simultaneous irruption of fire at numerous points in the most dangerous district; the momentary paralysis (by the earthquake) of every ordinary agency of warning, or call to aid; the blocking of streets, barring the way of the fire engines; the probable escape of gas from broken mains at many points; and most important of all, the (probable) complete failure of the water system soon after the earthquake shock. The influence of these factors was no doubt decisive as concerns the initiating of a conflagration; but it is doubtful whether they were of any large influence on the subsequent extension or duration of the fire.

On another page of this issue we print an abstract from the Fire Underwriters' report on San Francisco's conflagration hazard, issued about six months ago.* Because of the direct bearing of the water system of San Francisco on the calamitous fire, we give in connection with that report a full outline of the sources and paths of water supply to the city, and of the distribution system. At the present writing nothing whatever is known regarding the character of damage done to either the supply system or the distribution system, but this information, when it becomes available, may be expected to be of great interest.

Unfortunately, the fire in San Francisco has destroyed much evidence on the resistance of engineering structures to the earthquake. Most of the buildings in the burned district were leveled to the ground by the fire, and there will be nothing but hearsay evidence to tell whether they stood the seismic disturbance well or ill. In a lesser degree the same applies to the structures which were merely burned out, leaving the skeleton and shell standing firm; it will be difficult to unravel the tangle of earthquake and fire actions. The effects on wire distribution (telephone, telegraph, light and power) will also be a more or less confused mixture of earthquake and fire damage, and much important information as to earthquake damage will thereby be lost. On the other hand, most other structures, as water and gas distribution systems, and railways, will reveal the nature of the earthquake damages more clearly. And all structures in the affected region outside of San Francisco will, of course, show the effects of earthquake alone. A large aggregate fund of information should be gleaned from this, information of a kind almost non-existent in civilized countries outside of Japan.

It deserves important mention that the small cities in the earthquake district, outside of San Francisco, suffered devastation by fire in the same way as did the metropolis. Thus Santa Rosa and Fort Bragg send reports of conflagration following the earthquake.

THE EARTHQUAKE.

At 5.13 a. m. Wednesday, April 18, a strong earthquake shook the region already defined. The Berkeley (University of California) observatory reports that the tremors started with a series of vibrations lasting a little less than a minute, followed after about ten seconds by another strong series of half a minute. The vibrations are stated to have been S.S.E.-N.N.W. in direction, and to have had a long period, in the neighborhood of 1 sec. Milder tremors were felt in the region during the entire morning; these would have done no harm in themselves, but they appear to have shaken down loose parts here and there which were torn from place but not dislodged by the first shocks. In San Francisco, for example, many business buildings which had not been rendered impassable by the main shocks were thus rendered dangerous to occupants. Substantially, however, no earthquake damage was done after the first series of shocks.

The farthest north effects of the earthquake hitherto reported are at Eureka, Cal. (pop. 7,000), near Humboldt Bay, 215 miles north of San Francisco on the coast; here brick buildings were wrenched and water mains broken. At Point Arena (pop. 700) and Fort Bragg (pop. 2,000), 100 miles southerly, the lighthouses were "badly damaged," and at Fort Bragg all important buildings were leveled. A steamer reports that at sea off Humboldt Bay it felt the earthquake shocks very distinctly. The towns Ukiah (2,000), Healdsburg (2,000), Sebastopol (600) and Santa Rosa (7,000), 50 to 100 miles north of San Francisco, in the Sonoma Valley, all report very severe damage; again, "nearly all towns in the Sonoma Valley" are reported destroyed. Santa Rosa has probably 100 dead; with the exception of the California Northwestern Ry. depot every brick or stone building was wrecked.

Oakland (67,000) and Berkeley (13,000), 7 miles east of San Francisco across San Francisco Bay, suffered in much less degree; few buildings or other structures were destroyed, but many were so damaged that they will have to be torn down. The University of California at Berkeley suffered little damage. But farther east the Southern Pacific Co. suffered much disturbance of its railway lines, and many telegraph wires in that region were interrupted. A section of track between Oakland and Sacramento sank several feet; a railway bridge over the San Joaquin settled some inches. In general, however, no earthquake damage was done in the Sacramento and San Joaquin valleys and eastward.

The country around the lower half of San Francisco Bay, including the cities of San Francisco, Palo Alto, San Jose and a great number of small places, was badly shaken. San Jose (21,000) and Palo Alto (2,000) with the Leland Stanford University, experienced the greatest violence. The extensive university buildings, several of them of reinforced concrete construction, and most of them low buildings, were partly wrecked; it is reported that over half of them will have to be rebuilt. At San Jose many buildings were wrecked, and some 50 persons were killed outright in the collapse of buildings. An insane asylum near the city collapsed and killed many of the inmates. All towns in the region between San Jose and Salinas report heavy damage, as do also Salinas (3,500) and

*Elsewhere in this issue appears an abstract of the reports on New York and Chicago, which, by coincidence, we had some time ago prepared for publication this week.

Monterey (1,700). Nothing has been heard from the country south of Salinas, except that Los Angeles, 350 miles from San Francisco, did not feel the shock. On the other hand, the hamlet of Brawley, 500 miles southeast of San Francisco, in the famous Salton Sink depression, reports much damage. Traffic over the coast line of the Southern Pacific in the direction of Los Angeles is interrupted by a caved tunnel near Santa Cruz.

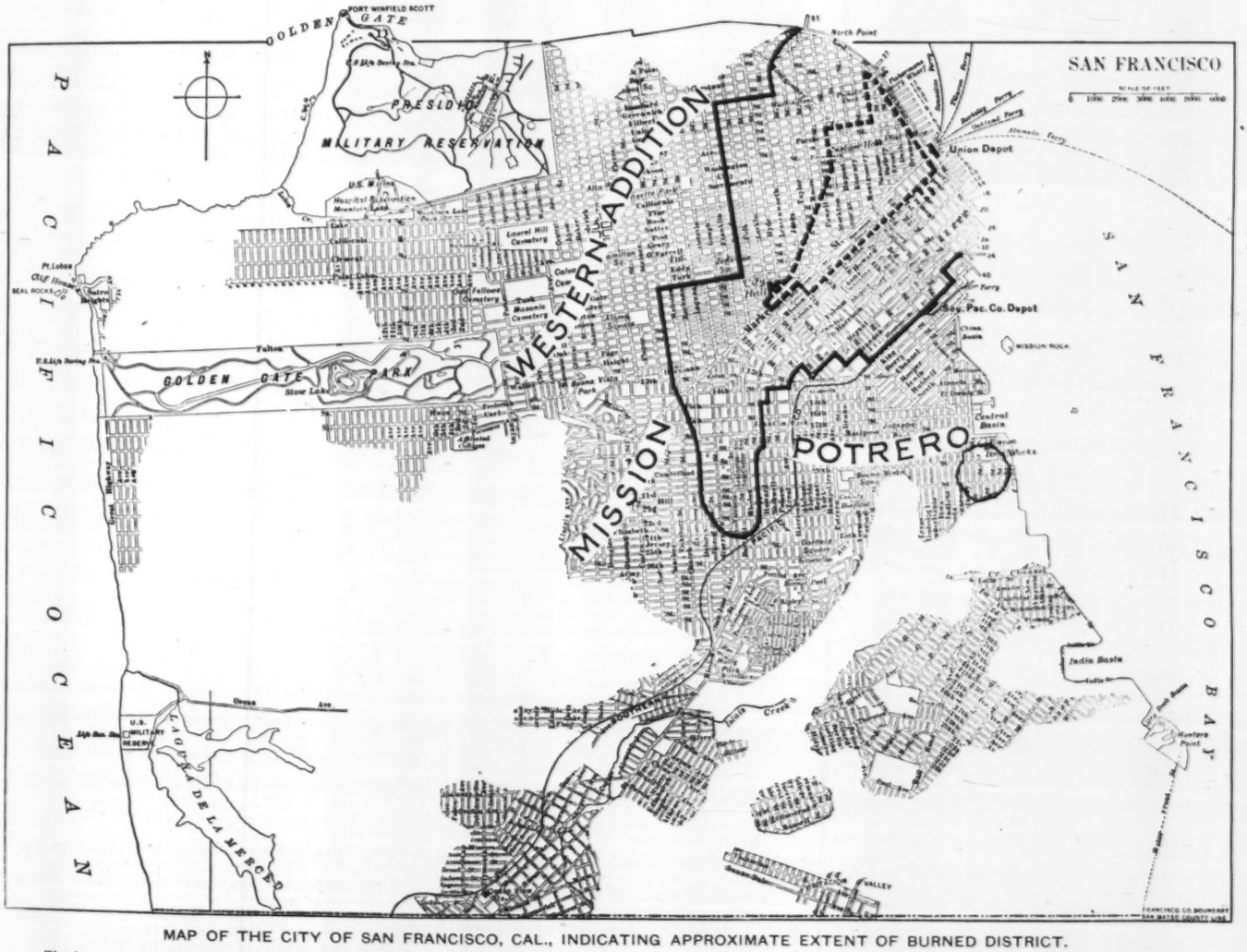
The earthquake damage in San Francisco has been passed almost unmentioned amid the fire news. Many buildings of ordinary brick shell construction and many wood frame buildings collapsed and buried the inmates. Heavily built structures like hotels of older types of construction, the Post Office, etc., were damaged in varying degree, in most cases, however, without impairing their structural integrity. The Post Office is said to be dangerously cracked, and settlement of the street directly in front is reported. The United States Mint, on the other hand, was little injured by the earthquake, and it was fortunately saved from the fire by great exertion and an independent water supply. Most of the damage appears to have been done in the low-lying northeast part of the city, Market street and southeast therefrom. This was a typical soft-ground foundation district throughout. Of the resistance of factory and shop buildings in this area nothing has yet been learned. A Navy dispatch states that the Union Iron Works, the Risdon Iron Works and the United Engineering Co. will be able to resume repair work soon. Three war vessels in course of construction at the first-named works are reported uninjured; but a passenger steamer on the ways toppled over and rolled on its side, and another steamer lying at the dock was struck by a falling crane and sunk. The chimneys of dwelling houses everywhere in the city were overthrown or cracked.

A most interesting experience, fully confirmatory of the expectations of structural engineers, is the general good resistance of steel-frame structures to the earthquake shock. There were in the worst affected district of San Francisco at least half a dozen structures of that type, from 10 to 17 stories high. As far as the vague and non-expert reports hitherto received give basis for judging, all these buildings passed through the violent vibrations of the earthquake without damage in their framework. Most of them suffered more or less damage by the fall of cornices, parts of walls, etc., but are unscathed in steel framework and in the larger part of their masonry. Special steel construction was represented in the great 100-ft. dome of the Parrott Building and the 60-ft. dome of the Hall of Records; both these were unaffected by the earthquake. A tall steel tower over the Market St. Ferry House (owned by the State) was badly racked; though it remained in use during the burning of the city it had been thrown out of plumb and on Saturday the 22d was condemned as unsafe. Other than these general remarks, no statement can be made at this time of the effect of the earthquake on modern buildings in San Francisco.

Perhaps the most important earthquake damage in San Francisco other than that to buildings was the injury done to the water and gas distribution systems. It is known that the water network, consisting of 97% cast iron pipe and 3% wrought iron pipe, was broken in a great number of places, so that the city was wholly without water supply throughout the fire. Yet by Friday afternoon, sixty hours after the earthquake, a supply from Lake Merced was got into the system, and this was reinforced in two more days by further supply from other reservoirs.

The amount of interference with the sewers cannot yet be learned. It is reported that the sewers in the burned district are virtually destroyed. Some use was made of the other sewers by Saturday, and at that time inspection and repair work on them was in most active progress.

There are many important engineering structures in the affected district, outside the cities. Unfortunately, after the first moments of the disaster, all attention and every means of communication was absorbed by the greater calamity developing in San Francisco, and only scattering



MAP OF THE CITY OF SAN FRANCISCO, CAL., INDICATING APPROXIMATE EXTENT OF BURNED DISTRICT.

The heavy broken line encloses the area within which nearly all buildings were of brick. Everything outside of this was mainly wood. (Natl. Bd. Fire Und., Conflagration Report on San Francisco, 1905.)

The heavy full line indicates the main area burned over by the conflagration of April 18-22, 1906, following the earthquake of April 18. The area of the burned district is about 7 sq. mi.

[A more precise statement of the limits of the burned district than formed the basis for the above map is contained in a dispatch sent on Monday, April 23, by E. E. Calvin, Vice-President of the Southern Pacific Co.:

Beginning in front of the Ferry House, and running south just inside the docks to corner Brannan and First Sts.; west on Brannan to Second; south to Townsend; west to corner Eighth and Division; westerly to Division and Harrison; south to Twentieth; west to Church; north to Market; east to Franklin; north to Jackson; east to Van Ness; north to the Bay; east along shore, destroying docks at Sansom, thence along East St. to point of beginning. Docks and piers south of Sansom were not burned.]

notes have been received concerning them, and such have all referred to works connected with communication. Several tunnels on the South Coast route of the Southern Pacific Co. caved in, stopping traffic south of San Jose. Many landslides occurred in railway cuts and on mountain sides. A lighthouse at Point Arena and one at Fort Bragg are reported wrecked. Telegraph lines south and north of San Francisco were paralyzed (but this may have been due to the San Francisco end only). The wires over the railway east from Oakland were not totally wrecked, but for 24 hours after the earthquake but few lines were working across the State of California. The Commercial Pacific cable to Hawaii, which landed at the western shore of the city, was not injured, it was learned on Friday. The Cable Hut, containing the shore-end terminal, was cracked but not destroyed, and on the second day it was rigged up as terminal station; communication around the world by this route was established Saturday.

Structures of very great importance but not directly concerned with communication are: The several high dams and long pipe-lines of the Spring Valley Water Co. supplying San Francisco; the long-distance high-tension electric transmission lines supplying San Francisco and nearby cities; and the two large dry docks at the Mare Island Navy Yard. The absence of detailed statement from Mare Island (on the bay, within 20 miles of San Francisco), although the authorities were in communication with Washington, makes it probable that the dry-docks, one stone and one concrete, were not seriously effected. The electric transmission systems extend into the districts north, northeast, southeast and east of San Francisco, passing through some of the most severely shaken areas. They include a 4,427-ft. single-span and cable crossing over Carquinez Straits near Port Costa.

Probably the most immediate interest attaches to the condition of the earth and masonry dams in the earthquake district. The description of San Francisco's water-supply system, given elsewhere in this issue, contains the names, locations and dimensions of these structures. No word as to their present state has found its way into the press dispatches. But the fact that partial restoration of the water supply to the city has been accomplished and the full supply is promised for the near future, together with the absence of news of inundation or other evidence of leakage, encourages the hope that all these structures came through the disturbance without harm.

THE SAN FRANCISCO CONFLAGRATION.

Refugees have stated that dangerous fire (or fires) was in progress in the Market St. district and in the Mission district within half an hour after the earthquake, and it is certain that in three hours hundreds of buildings were in flames and the conflagration was in full progress. While the reports are not clear, it seems that at least three separate fires developed, joining later in a single great burning area. In the absence of water supply, the fire engines were of little service, being dependent on the bay, while the fire extended two miles from the nearest point of the water front. Dynamiting blocks of buildings in the path of the fire to form open spaces able to hold the advance was early resorted to. The direction of the wind, easterly, drove the fire directly across the city, with four miles of buildings ahead of it. On Thursday afternoon the city authorities resolved to make a last stand at Van Ness Ave., a 90-ft. street lying across the fire's course. Fifteen or sixteen blocks of residences along one side of this street were leveled to the ground by means of cannon, guncotton and black powder—the dynamite had been exhausted the day before. Shortly after the flames crossed the gap so created, the wind turned to the west, and in a few hours the fire was turned back from its advance.

The city of San Francisco had no fireboats, in spite of its extensive water-front, valuable shore property and combustible building construction. Tugboats of the Harbor Commission, of the railway companies and of the Government authorities seconded the work of the city fire engines along the water-front. A large portion of the northeastern wharfage was thus saved. In particular the State Ferry House, at the foot of Market St., was saved from the fire; this was a vital point of the situation, as it was for two days the sole line and at all times by far the most important line of communication with the rest of the world for telegraph, passengers and freight.

The remnants of the fire, after its check late Thursday night, were under control by Sunday, April 23, and in the following night a heavy rain, the first since the earthquake, finally extinguished the flames.

The extent of the fire damage is indicated on the accompanying map by a heavy black line. All within this line was completely burned over; only the United States Mint, the Western Electric Company's factory building, and perhaps one or two other structures were passed over unharmed, and these were saved by independent water supply and hard fighting.

This area, about 7 sq. mi., includes the entire office, business, hotel and "downtown" district generally; the entire tenement district; the finest and wealthiest residence section; the factory and warehouse district; and a large residential area of middle class. We have also shown on the map, by a broken line, the approximate extent of the "mainly brick buildings" district as delimited by the National Board of Fire Underwriters in their Conflagration Hazard report on the city. This district is the downtown section.

The results of the fire, as regards specific engineering interest, are substantially of the same kind as obtained at Baltimore. There is good reason to believe that the high temperature of the Baltimore fire was not reached, an effect attributed in part to the peculiarly dull combustion of redwood, a material widely used there. Thus, the "Call" Building, burned out in its lower portion, is said to be practically free from fire damage in the upper stories. But this building is an exception in this respect. Office buildings generally were gutted as thoroughly as at Baltimore.

Many scattered items of information are already at hand to indicate roughly the damage done by the fire to the more important buildings in the city. But in the absence of reasonably specific news a recital of them at present may be omitted. It is to be noted, moreover, that the final record of the conflagration effects and the resistance of "fireproof" structures will be imperfect and questionable in many respects when compared with the record of the Baltimore fire. To differentiate the effects of earthquake and fire and define their mutual influence will prove a difficult and unsatisfactory task.

THE STATISTICS OF SAULT CANAL TRAFFIC for the season of 1905 have been compiled and published in a neat pamphlet issued under direction of Major Charles E. L. B. Davis, Corps of Engineers. The total net registered tonnage passing both canals at the Sault, American and Canadian, in 1905 was 36,617,700. Other statistics of the total traffic are as follows:

Total mile-tons	36,892,797,973
Total freight carried, tons	44,270,680
Total valuation placed on freight carried..	$416,965,484
Average value per ton of freight carried...	$9.42
Total amount paid for freight transportat'n.	$31,420,584.54
Average distance freight was carried, miles	833.3
Cost per mile per ton, mills	.85
Average cost per ton for freight transportation	$0.71
Total number of registered vessels using canals	910
Total number of passages by unregistered crafts carrying freight	720
Time American Canal was operated, days..	246
Time Canadian Canal was operated, days..	255
Total valuation placed on registered vessels.	$78,640,300
Total number of passengers transported...	54,204

THE POSTAL CABLE between Manila, P. I., and Shanghai, China, which was delayed by the political upheaval in China and later by the war between Japan and Russia, was completed April 17. The laying of this cable now gives direct cable connection between San Francisco and Shanghai, and as desired by the Government at Washington, has terminals only on American soil, these being operated by American operators.

To complete this line required nearly 10,000 miles of submarine cable, which is laid at an average depth of 2,640 fathoms (15,840 ft.), the greatest depth on the line of cable being 3,490 fathoms (20,940 ft.). China's end of the cable is laid up the shallow waters of the Yangste Kiang River to Paoshan, where it ends in a hut. From Paoshan the line is connected by underground wires to the Commercial Pacific office at Shanghai. The cable extends from San Francisco to Honolulu, to Manila by the way of Guam and from Manila to Shanghai.

A GREAT STEEL MANUFACTURING PLANT involving a total investment of probably $75,000,000, is planned by the United States Steel Corporation, to be built on the shores of Lake Michigan just east of the boundary line between Illinois and Indiana. Around the plant will be built an industrial town, to be named Gary, after the present Chairman of the Board of Directors of the Steel Corporation. According to newspaper accounts, the complete plant will comprise 16 blast furnaces, open-hearth furnaces and 6 rolling mills. Vessels will reach the plant through the Calumet River.

A NEW LAKE PASSENGER STEAMER is to be built for the Detroit & Cleveland Steam Navigation Co., and is to embody a number of special features, including passenger elevators serving the five principal decks. The main saloon will be three decks high, having galleries for the upper rows of cabins. The steamer will be 400 ft. long, 54 ft. beam, 90 ft. wide over the guards and 22 ft. deep in the hold. Three-cylinder engines of 7,000 HP. will drive side wheels fitted with feathering floats, and steam will be supplied by eight Scotch boilers. A speed of 20 miles an hour is expected. The vessel was designed by Mr. Frank E. Kirby, of the Toledo Shipbuilding Co.

EXPORTS OF IRON AND STEEL from the United States have increased from $9,000,000 in the eight months ending with February, 1870, to $102,000,000 in the corresponding months of the present fiscal year, while the imports have decreased from $21,000,000 to $18,000,000 for the corresponding period. The following is an extract of the report of the Department of Commerce and Labor through its Bureau of Statistics:

The principal articles comprising this exportation of 143 million dollars' worth of iron and steel during the last calendar year, stated in the order of their magnitude, were: Miscellaneous machinery, 25 million dollars; builders' hardware, saws and tools, 12½ millions; pipes and fittings, 8½ millions; electrical machinery, 7⅞ millions; steel rails, 7½ millions; wire, 7 millions; sewing machines, 6½ millions; locomotives, 5⅝ millions; metal-working machinery, 5⅜ millions; and typewriters, 5 millions of dollars. Other important items of less than 5 million dollars' value each were: Billets, ingots, and blooms, 4¾ million dollars; structural iron and steel, 4½ millions; sheets and plates, 3⅞ millions; pumps and pumping machinery, 3¼ millions; nails and spikes, 2½ millions; cash registers, 2⅛ millions; firearms, 1¾ millions; castings, 1⅝ millions; steel bars or rods, 1½ millions; printing presses, 1⅓ millions; shoe machinery, 1⅛ millions; bar iron, 1¼ millions; and stoves, 1 million dollars; these twenty-three classes supplying in 1905 fully 80% of the total exportations of iron and steel.

As to the destination of iron and steel exports, South America and Mexico are the best customers for our steel rails; Canada, the United Kingdom, and Australia take most of our builders' hardware; electrical machinery goes chiefly to Canada, Japan, Mexico, and Great Britain; sewing machines, chiefly to the United Kingdom, Germany, Argentina, Mexico and Holland; most of our locomotives to Japan; typewriters, chiefly to the United Kingdom and other European countries.

The following table shows the production of pig iron in the United States and the value of iron and steel manufactures imported and exported, respectively, at decennial periods from 1870 to 1900 and annually from 1900 to 1905:

Calendar year.	Pig iron production. Million tons.	Iron and steel manufactures. Imports. Million dollars.	Exports. Million dollars.
1870	1.7	37.4	18.9
1880	3.8	64.0	15.5
1890	9.2	45.0	27.0
1900	13.8	20.4	130.0
1901	15.9	20.4	101.5
1902	17.8	41.5	98.0
1903	18.0	41.2	99.0
1904	16.5	21.6	128.5
1905	23.0	26.4	142.9

THE LAWRENCE AVE. SEWER TUNNEL of the Chicago intercepting sewer system is now under construction again, after some years' delay due to the failure of the original contractors and litigation following the city's attempt to complete the work by day labor. The Supreme Court of Illinois finally rendered a decision that the work must be done by contract, as the law required all work costing more than $500 to be publicly advertised and let to the lowest bidder. The city had already built a portion of the intercepting sewer system by day labor, and believed that it could do it cheaper than by contract. The tunnel is 16 ft. diameter, with its invert about 35 ft. below the surface, and its length from Lake Michigan to the Chicago River will be 8,220 ft. It will be mainly in blue clay. The work is being done by M. H. McGovern, of Chicago, and the contract price is $79.50 per lin. ft.

A STEAM MOTOR CAR is to be introduced on the Erie Ry., the steam truck or motive-power equipment of which (with engines, boiler, etc., complete) is being built by Ganz & Co., of Austria. The boiler will be of the water-tube type, 33 ins. diameter and 40 ins. high, using

either oil, coke or anthracite coal, and carrying a pressure of 250 to 300 lbs. Each of the two axles of the steam truck will be driven by its own 50-HP. engine. The car will be 57 ft. long, seating 60 passengers and weighing about 35 to 40 tons in working order. It is stated that this car and a gasoline motor car of the type invented by Mr. McKeen, of the Union Pacific Ry., are to be operated on the New Jersey & New York branch, between Jersey City and New City, N. Y., about 33 miles. Both the Gast and McKeen motor cars have been described in our columns.

A RAILWAY MOTOR CAR is to be tried on the Lake Shore & Michigan Southern Ry.; it will be operated by a gasoline-electric system devised by Mr. F. L. Chase, President of the Jamestown, Chautauqua & Lake Erie Ry. A special feature of the arrangement is that all the machinery is below the floor, leaving the entire car body available for passenger accommodation. The engine will, it is said, be of 200 HP. The car has been built by the Kuhlman Car Co., of Collinwood, O. It is 34 ft. 4 ins. long in the body, 43 ft. 9 ins. long over the vestibules, 9 ft. wide; 8 ft. 11 ins. high inside, 3 ft. 6 ins. high from rail to bottom of sills, and 13 ft. 4 ins. from rail to roof. It has 6-in. I-beam center sills and yellow-pine side sills. The interior has a main compartment for 26 passengers and a smoking compartment for 16 passengers, together with toilet room and heater compartment. The machinery equipment will be built and installed at the railway shops at Collinwood.

RAILWAY MOTOR CARS for South America and India show the widespread tendency to introduce this system of economical transportation in railway service. Both of these are steam cars. The car for the Southern Railway of the Argentine Republic is 65 ft. long over the pilots, and the body is divided into two passenger compartments of 28 first-class and 24 second-class passengers; the former is entered from the rear vestibuled platform, and latter is entered from a transverse gangway or vestibule between the passenger compartment and baggage compartment. The vestibules have steps coming close to the ground, and are protected by ornamental iron gates. The seats are arranged as in American cars. The rear end is carried by a four-wheel truck, while at the forward end the sills are extended to carry a bolster with center-plate bearing on the bolster of the steam truck, this truck being detachable. A small boiler of the locomotive type is placed across the frames, and has the fire door in one side of the fire-box; a curved flue extends from the smoke-box to a central smoke-stack. The wheels are 3 ft. 4 ins. diameter, with a wheelbase of 9 ft. 6 ins., but they are not coupled. Outside cylinders 9½ × 15¾ ins. drive the rear axle. The car built by the Vulcan Foundry Co., England, for the Northwestern Ry. of India, is in general similar to the above, and is 60 ft. long over all, with a distance of 41 ft. 6 ins. between truck centers. The steam truck has a boiler of the locomotive type, with the smoke-box at the end next to the car body, and thus runs with the cab in front. The outside cylinders are 9 × 15 ins., placed between the axles and driving the front axle. The wheels are 39 ins. diameter, but are not coupled. The boiler has 252 sq. ft. of tube heating surface, 300 sq. ft. total heating surface, and 9 sq. ft. of grate area; it carries a pressure of 160 lbs. The tanks have a capacity of 300 gallons, and the coal bunker has a capacity of 18 cu. ft. The car has three compartments for three first-class, three second-class and 72 third-class compartments. The total weight is 43.5 tons, of which 25.2 tons are on the steam truck and 18.3 tons on the rear truck. Both of the railways mentioned have a gage of 5 ft. 6 ins.

RAILWAY ACCIDENT statistics for the three months ending Dec. 31, 1905, according to the Interstate Commerce Commission, shows the total number of casualties to passengers and employees to be 18,227 (1,109 killed and 17,118 injured). This is an increase of 56 in the number killed and 732 in the number injured over those reported in the preceding three months, and an increase of 158 in the number killed and 3,001 in the number injured in the same quarter one year ago.

The number of passengers and employees killed in train accidents was 320, as against 272 in the preceding three months and 242 in the same quarter one year ago. The injured numbered 3,797, as against 3,455 in the preceding three months and 3,298 in the same quarter one year ago.

The total number of collisions and derailments was 3,722 (2,077 collisions and 1,645 derailments), of which 207 collisions and 183 derailments affected passenger trains. The damage to cars, engines and roadway by these accidents amounted to $2,817,294.

The number of employees killed in coupling and uncoupling cars and engines was 85, as against 74 in the preceding quarter and 71 in the same quarter one year ago. The injuries to employees from this cause numbered 806, as against 817 in the preceding quarter and 832 for the same quarter one year ago.

MALLET DUPLEX COMPOUND LOCOMOTIVES are being built at the Baldwin Locomotive Works for road and pusher service on the great Northern Ry. They are to assist the regular road engines in hauling trains of 2,000 tons at moderate speed on a grade of 2.2%, 32 miles long. Their tractive power is estimated at 71,600 lbs. The engines will be very similar to the pusher engine of the Baltimore & Ohio Ry., described in our issue of June 30, 1904, but will have a two-wheeled truck at each end in order to reduce the wear on the flanges of the driving wheels. They will thus be of the 2-6-6-2 type, instead of 0-6-6-0, as on the Baltimore & Ohio R. R.

BUILDING LAW REVISION is being taken up in Washington, D. C. The Commissioners of the District of Columbia have appointed a committee of ten citizens, representing builders, architects, contractors, lawyers, real estate operators, and merchants, to review the building regulations of the District with a view to making important changes. The committee consists of Messrs. F. L. Averill, A. P. Clark, Jr., L. Dezzez, G. M. Kober, J. L. Parsons, T. W. Power, J. Richardson, W. B. Upton, N. Wilson and S. W. Woodward. The regulations now in force were made several years ago, and although they are said to have been generally satisfactory, it has been found necessary to change them occasionally. The committee will not do the actual work of revising the regulations, but the Commissioners expect it to make a general review of the regulations, to make recommendations as to which sections should be revised, and to give opinions on the general features and scope of the regulations.

TIE-PRESERVING PLANTS are to be established by the Northern Pacific Ry. at Brainerd, Minn., and Coeur d'Alene, Idaho. They will be for creosoting on the Lowry process, and will be designed and built by the Columbia Creosoting Co., of Shirley, Ind., of which Mr. C. B. Lowry is General Manager. The plants will be practically duplicates of the one at Shirley, which is now being operated under a ten-year contract with the Cleveland, Cincinnati, Chicago & St. Louis Ry., calling for the treatment of at least 600,000 ties per year, at 30 cts. each. This plant has two cylinders 7 × 130 ft., with a capacity of about 2,000,000 ties per annum. The oil from tank cars is pumped into two storage tanks of 160,000 gallons capacity, and thence to two 30,000-gallon tanks, from which it is supplied to the cylinder; the oil from the cylinders is drained into an underground tank of 38,000 gallons capacity. In the Lowry process no preliminary steaming or vacuum is employed, but the cylinder is at once filled with oil and a pressure of 180 lbs. gradually obtained. The oil is then drawn off, and as the pressure is reduced the air in the cells of the wood expands and drives out the creosote, leaving the cell walls impregnated. A final vacuum draws off the oil remaining at the surface of the wood. Red oak, hard maple and beech ties absorb about 4½ gallons each, and soft maple about 5½ gallons; the final amount left in the ties is about 2½ gallons per tie. The tie cars are handled by electric locomotives on the Morgan third-rail system. Each car will hold 52 to 56 ties, and 15 cars form a charge for the cylinder.

THE GOLD OUTPUT IN THE TRANSVAAL, according to the report of Mr. U. P. Swinburne, Acting Mining Engineer for the Transvaal Mines Department, was valued at some $90,000,000 for the year ending June 30, 1905. During the year a total of 173,221 men were employed in the Transvaal gold mines, as compared with 182,287 in all the mines of the Transvaal. Of the larger number, 18,510 were whites, 122,437 were colored, and 41,340 were Chinese. This was an increase of about 78,000 over the previous year, of which increase more than half were made up of the Chinese, none of which were employed in 1903-04.

THE RATE OF INCREASE OF EARTH TEMPERATURE with the depth on the Witwatersrand gold field is said to be 1° F. for each 208 ft. of depth, or 0.48° F. for each 100 ft. of depth. With a mean temperature of 68.75° F. at a depth of 1,000 ft., a temperature of 102.35° is reached at a depth of 8,000 ft. The natural ventilation of the mine decreases the rock temperature in the vicinity of the workings from 5° to 10° F. The above data are taken from a paper by Mr. Hugh F. Marriott presented before the Institution of Mining and Metallurgy of London on March 15.

PORTABLE CONVENIENCE STATIONS for street improvement gangs are suggested in the Grand Rapids "Civic News" of April 14. The idea is credited to Mr. Gilbert Hart, of Detroit, and is set forth as follows:

These stations might be constructed with a frame of gas pipe covered with canvas, with a floor and a movable box or tub. Handles should be provided so that the station could be carried along with the gang and placed in an alley or on a vacant lot convenient to the place of work. The box or tub should be partly filled with earth and emptied as often as convenient or necessary. The provision of these convenience stations would remove a nuisance which often becomes a menace to health and is highly offensive to residents in the vicinity where street work is going on. We are advised that this suggestion was made to the health officer of Detroit more than a year ago and met with his hearty approval. Nothing seems to have come of it, however, and it may be necessary to have an ordinance passed requiring that such convenience stations be provided with all street work done by gangs.

BRIQUETTING MACHINERY for handling coal, coal dust, ore, and sand and lime or clinker and lime mixtures is manufactured extensively in England, and an improved form of a commercial machine, built by Bradley & Craven, of Wakefield, has recently been described in "The Engineer," of London. The machine has a horizontal table with eight sets of molds, each set making four briquettes. The table is revolved by a ratchet motion worked by an eccentric on a shaft driven by bevel gearing from the main shaft. It makes one-eighth of a revolution (45°) at each movement, and is held in position by a catch while the briquettes are made and ejected. The pressure is applied at both top and bottom of the mold by means of plungers carried by two heavy rocking beams, one above and the other below the table. These are driven by connecting rods from a crank shaft, and give a pressure of about 2½ tons per sq. in. upon the material in the mold. At the discharging point, the briquettes are ejected by a piston working from below, and as soon as they are clear of the top of the table, a horizontal ram pushes them onto a conveyor belt. The table makes two revolutions per minute, which gives a production of 64 briquettes per minute. The materials are first passed through a crusher, and then to the mixer, where the cementing medium or binder is added, and the mixture then goes to the heater, from the hopper bottom of which it is fed through a sliding door to a feeder which delivers it into the molds. The molds being filled, the table makes a partial revolution, bringing the four freshly filled molds between the rams or plungers, while at the same moment four compressed briquettes are ejected from four molds in advance and four empty molds behind are refilled. For coal briquettes for domestic fuel a mixture of about 16 parts of coal to 1 of pitch is used. The heater is heated by superheated steam which issues from coils of perforated pipe, the pressure being 80 to 100 lbs. to prevent the fine material from clogging the holes.

ADVERTISING FOR BIDS on a patented or copyrighted article is not required by the City Charter of Baltimore, according to an opinion recently given by the Baltimore City Solicitor. The charter requires advertising to secure competition; but,

to advertise for bids in such a case would result in no more than a proposal from one bidder, because only one bidder has the desired commodity for sale. Therefore, this object of the charter could not be attained. Similarly, favoritism, extravagance, corruption and improvidence could not be prevented by advertisement in such a case, because where there could be only one bidder the danger of these things is just as present with an advertisement as without it.

PERSONALS.

Mr. John McNeal, Jr., M. Am. Soc. C. E., has been elected City Engineer of Easton, Pa.

Mr. Grier Hersh has been elected President of the York Street Railway, York, Pa., to succeed Capt. W. H. Lanius.

Mr. R. A. Watts has been appointed Superintendent of the Missouri River & Northwestern Ry., with headquarters at Rapid City, So. Dakota.

Mr. G. A. Lund, General Manager for Milliken Bros. in South Africa, has just returned to New York City, after completing his three-year engagement.

Mr. R. E. Merrick, formerly with the Buda Foundry Co., Chicago, has been appointed Chief Engineer of the Pacific & Idaho Northern Ry., with headquarters at Weiser, Idaho.

Mr. D. W. Gross, Assoc. M. Am. Soc. C. E., has been appointed Engineer of Roadway of the new Third Division of the Atlantic Coast Line R. R., with headquarters at Jacksonville, Fla.

Mr. W. J. Douglas, Engineer of Bridges of the District of Columbia, was married April 17 at New Brighton, Pa., to Miss Elizabeth Appleton Spalding, daughter of the Rev. Charles N. Spalding.

Mr. Edward C. Sherman, Assoc. M. Am. Soc. C. E., Assistant Engineer Charles River Basin Commission, has been promoted to Division Engineer in charge of the office force of the Commission.

The following changes have taken place in the personnel of the Reclamation Service: Mr. C. K. Hosford, Assistant Engineer and E. W. Vernier, Engineering Aid, have resigned from the service.

Mr. Merle H. Reed, formerly Assistant Engineer, Missouri Pacific Ry., and recently Chief Engineer of the Clarksville & Fort Smith Electric R. R., has been elected City Engineer of Fort Smith, Ark.

Mr. W. H. Kirkbride, formerly Roadmaster of the Southern Pacific Ry., at Red Bluff, Cal., has been ap-

pointed Assistant Resident Engineer, Sacramento Division of the Southern Pacific Ry., with headquarters at Sacramento, Cal.

Mr. Frank B. Test, formerly Engineer and Inspector with the Committee of Twenty of the National Board of Fire Underwriters, has been appointed Assistant Engineer in the office of the Third Vice-President of the United Gas Improvement Co., with headquarters at Philadelphia, Pa.

Mr. F. H. Bainbridge, recently Assistant Chief Engineer of the Chicago & Northwestern Ry., has been appointed Engineer of the Pierre & Fort Pierre Bridge Ry. Co., at Pierre, So. Dak. The bridge is to carry the Rapid City extension of the Chicago & Northwestern Ry. over the Missouri River.

Mr. A. E. Aeby, who has been Sales Agent at the New York office of the Pennsylvania Steel Co. for the past 18 years, and who has been the company's New York representative since the resignation of Stephen W. Baldwin four years ago, has resigned to accept the position of General Manager of the Carbon Steel Co. Mr. John C. Jay, Jr., his assistant, has been appointed to succeed him.

Mr. Theodore L. Condron, M. Am. Soc. C. E., with offices at 1741 Monadnock Block, Chicago, Ill., announces that he has associated with him Mr. F. F. Sinks, his principal assistant, under the firm name of Condron & Sinks, to carry on the business of preparing designs for and superintending the construction of steel and reinforced concrete structures. Their offices are at 1741 Monadnock Block.

Prof. Edward B. Van Vleck, Ph. D., Professor of Mathematics at Wesleyan University, has been appointed Professor of Mathematics at the University of Wisconsin in place of Prof. C. A. Van Velzer, resigned. Prof. Van Vleck is a graduate of Wesleyan, and besides having taken graduate work at John Hopkins he pursued a three years' course at the University of Göttingen, Germany, from which he received the degree of Doctor of Philosophy in 1893. Prof. Van Vleck became Instructor in mathematics at the University of Wisconsin upon his return to this country, resigning in 1895 to become Professor of Mathematics at Wesleyan.

Prof. W. D. Pence, M. Am. Soc. C. E., head of the Department of Civil Engineering at Purdue University, has been elected to the Chair of Civil Engineering of Wisconsin University, to fill the vacancy caused by the resignation of Mr. W. D. Taylor, who has become Chief Engineer of the Chicago & Alton Ry. Prof. Pence is a graduate of the University of Illinois and for six years following his graduation he was employed by the Atchison, Topeka & Santa Fe Ry. as Assistant Engineer, Roadmaster, Assistant Engineer of Maintenance of Way and Resident Engineer. In 1892 he became a member of the Faculty of the School of Engineering of the University of Illinois, resigning to become the head of the Department of Civil Engineering of Purdue in 1899. Prof. Pence was a member of the commission appointed to study the drainage of the Kankakee marshes, and is the author of a treatise on "Stand-Pipe Accidents and Failures," and Editor of the publications of the American Railway Engineering and Maintenance of Way Association.

Obituary.

William A. Rudd, Boston, General Manager of the Western Union Telegraph Co., died April 13 at Boston, Mass., aged 50 years.

Richmond W. Wheeler, President of the Bushnell Pump Co., Bushnell, Ill., died April 11 at Bushnell, of pneumonia, aged 34 years.

Harley Laing, Superintendent of the Racine Water-Works Department, Racine, Wis., died of apoplexy at Milwaukee, Wis., aged 30 years.

Joseph Bailey, General Manager of all the soft coal companies connected with the Erie R. R., died at Dubois, Pa., April 10 of heart disease, aged 50 years.

Lemuel Bannister died April 13 at New York City of cancer, aged 65 years. Mr. Bannister was formerly First Vice-President of the Westinghouse Electric & Manufacturing Co., Pittsburg, Pa.

Francis Lewis Sperry, M. Am. Inst. M. E., died at Tallmadge, O., April 17, aged 44 years. Mr. Sperry was a well-known mineralogist and chemist and the discoverer of "Sperryite," which was named after him. He was a graduate of Sheffield Scientific School of Yale University.

Francis H. Saylor died April 13 at Germantown, Pa. He was born in 1844 at Schuylkill Haven, Pa., and was graduated from Amherst College in 1865 and from the Rensselaer Polytechnic Institute in 1868. Mr. Saylor superintended, as Chief Engineer, the construction of the Pittsburg & Lake Erie R. R.

Louis Brown died at New York City April 11 of pneumonia, aged 42 years. He was a graduate of the College of the City of New York and for several years was connected with McKim, Mead & White, but at the time of his death he was associated with Mr. George C. Palmer and Mr. Henry F. Hornbostel, architects.

William Fayette Boardman died at Oakland, Cal., April 14. Mr. Boardman was born at Salisbury, Conn., in 1824, removing to California in 1851. The route of the Central Pacific R. R. from the summit of the Sierra Nevadas to Truckee was laid out by him, and he also made a survey of the city of San Francisco. Later he became City Engineer of Oakland and then Surveyor of Alamenda County.

Henry Ward Beecher Howard, Assistant Secretary and Treasurer of the American Institute of Mining Engineers, died April 16 at Brooklyn, N. Y., of kidney disease, aged 57 years. He was a graduate of Yale and had been Bursar of the Brooklyn Polytechnic Institute for many years. He resigned as Bursar to become assistant to his cousin, Prof. Rossiter W. Raymond, Secretary of the American Institute of Mining Engineers.

Prof. Pierre Curie, the discoverer of radium, was run over April 19 on the Palace Dauphines, Paris, France, and killed. Prof. Curie was born in Paris in 1859 and was educated at the Sorbonne. He began scientific research work on his own account while an assistant in the School of Chemistry, Paris. He was made a professor in 1895, and about this time he married Marie Slodow Slowdowska, who assisted him in his future research work. They spent several years studying uranium and thorium, but it was not until 1903, while working on the salts of uranium that they discovered radium. In 1901 the French Academy of Sciences awarded M. Curie the La Caze prize of 10,000 francs and commended his wife for her part in the research. They received in December, 1903, the Noble prize for chemistry and 60,000 francs as part of the Osiris prize of France. M. Curie was also offered the red ribbon of the Legion of Honor in 1904, but refused to accept it.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN ELECTROCHEMICAL SOCIETY.
May 1 to 3. Annual meeting at Ithaca, N. Y. Secy., S. S. Sadtler, 39 South 10th St., Philadelphia, Pa.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 1 to 4. Semi-annual meeting at Chattanooga, Tenn. Secy., F. R. Hutton, 12 West 31st St., New York City.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 22 to 24. Annual meeting at Chicago, Ill. Secy., W. H. Merrill, Jr., Chicago, Ill.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
May 28 to June 1. Annual convention at Milwaukee, Wis. Secy., Ralph W. Pope, New York City.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
June 5. Annual meeting at Atlantic City, N. J. Secy., W. C. L. Eglin, 136 Liberty St., New York, N. Y.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
June 5 to 7. Annual convention at Cleveland, O. Secy., Richard Moldenke, Watchung, N. J.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 18. Annual convention at Atlantic City, N. J. Secy., J. W. Taylor, Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 13. Annual convention at Atlantic City, N. J. Secy., J. W. Taylor, 658 Rookery, Chicago, Ill.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 21-23. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 26. Annual convention at Thousand Islands, N. Y. Secy., Chas. Warren Hunt, 220 West 57th St., New York, N. Y.

AMERICAN WATER-WORKS ASSOCIATION.
July 10 to 14, inclusive. Annual meeting at Boston, Mass. Secy., J. M. Diven, 14 George St., Charleston, S. C.

AMERICAN INSTITUTE OF MINING ENGINEERS.
July 23 to Aug. 4. Joint meeting with the Iron and Steel Institute at London. Secy., R. W. Raymond, New York City.

AMERICAN ELECTROCHEMICAL SOCIETY.—The ninth general meeting of the society will be held at Ithaca, N. Y., May 1 to 3. All meetings will be held in the Chemical Laboratory, Morse Hall, Cornell University, while the Ithaca Hotel will be hotel headquarters.

Meetings for the reading and discussion of papers will be held Tuesday, Wednesday and Thursday mornings, when 34 papers on electrochemical and chemical subjects will be presented.

The afternoons and evenings will be given up to sight-seeing and pleasure, several trips, etc., having been arranged.

FOREIGN TOURS OF AMERICAN ENGINEERING SOCIETIES.—Europe is to witness several important gatherings of engineering societies during the months of June and July.

The Associazione Electrotecnica Italiana has extended an invitation to the American Institute of Electrical Engineers to visit Italy during the Milan Exposition, the visits contemplated including Naples, Rome, Florence, Genoa, Turin, Milan (Exposition), and Venice. The party will assemble at Milan June 1 and after visiting the Exposition will undertake the tour as outlined returning June 15. From June 23 to July 7 the Institution of Electrical Engineers will entertain the kindred institutions of Canada, France, Germany, Italy, Switzerland and United States. Visitors will register in Central Committee Rooms, at the Hotel Cecil, London, June 2[illegible] the following days being employed in visiting [illegible] interest about London, Manchester, Liverpool, Edinburgh, Newcastle and Leeds.

The Iron and Steel Institute and the American [illegible] of Mining Engineers hold a joint meeting [illegible] during the week commencing July 23. Meetings [illegible] reading and discussion of papers will be held [illegible] mornings of July 24, 25 and 26, with visits to [illegible] the afternoons. After the London meeting visits [illegible] made to York, Middlesbrough, Newcastle-on-Tyne, [illegible] gow and Edinburgh.

WESTERN SOCIETY OF ENGINEERS.—At [illegible] ing held at the society's rooms, Chicago, on [illegible] 18, the paper presented was by Mr. C. H. Cartlidge, [illegible] Engineer of the Chicago, Burlington & Quincy [illegible] "The Design of Swing Bridges from a Maintenance [illegible] point." It is printed on p. 465 of this issue.

In the discussion Mr. W. H. Finley (C. & N. W. [illegible]) preferred the combined center and rim-bearing [illegible] ment; he was surprised at Mr. Cartlidge's objection [illegible] to conical rollers, as there are a number of bridges [illegible] the Chicago & Northwestern Ry. which have center [illegible] with conical rollers, and after several years' service they are still in good condition. It is, however, largely a matter of design and material; if the length is very much greater than the diameter the roller is liable to give trouble unless held in line. As to end lifts he preferred a toggle arrangement. Mr. Loweth (C. M. & St. P. Ry) did not agree with Mr. Finley as to the end-lift, but preferred a wedge to a toggle arrangement. As to the rail lifts, while Mr. Cartlidge's design allowed the rails to drop by gravity he considered it better to have them pulled back positively into position for the rail joints at these lifts he is now replacing square joints with lap joints in order to reduce the wear and pounding. Mr. B. B. Carter considered it better to bolt the rack to a vertical face rather than to a horizontal face as in the designs shown in the paper. The discussion is to be continued at a later meeting.

WESTERN RAILWAY CLUB.—At the regular meeting held at the Auditorium Hotel, Chicago, on April 17, the subject of changes in the rules of interchange was first discussed, and was followed by a most interesting discussion on the compound locomotive. This discussion was started by the presentation by Mr. J. H. De Voy, Mechanical Engineer of the Chicago, Milwaukee & St. Paul Ry., of a thesis prepared by students of the University of Wisconsin giving the results and conclusions of a comparative test between simple and compound freight locomotives in regular service on the Chicago, Milwaukee & St. Paul Ry. The tests were made under the supervision of Prof. Storm Bull, but it was shown that the deductions were based mainly on theoretical conditions and did not agree with the results of long-extended service tests on a great number of roads. The general conclusions presented in the thesis were unfavorable to the compound in point of economy, but it was argued that such conclusions were incorrect. Mr. A. E. Manchester (C. M. & St. P. Ry.) stated that his road has 250 compounds and is likely to increase the number, but that they show higher economy in fuel consumption on divisions where the trains are slow and heavy than where a fast schedule and lighter trains are the rule. Thus it is necessary to determine which divisions can best be operated with the compounds. On the other hand, compounds are not well adapted for divisions where the roundhouse organization is not fitted for making the necessary repairs. As to the cost of repair work, the compounds (built at contract shops) show a higher cost, but he was strongly of opinion that with both compound and simple engines built at the company's shops there would be practically no difference. Mr. J. H. De Voy (C., M. & St. P. Ry.) took exception to the statement that in the Vauclain compound, the amount of work in the high and low pressure cylinders (coupled to one crosshead) is so unequal as to set up great strains in the crosshead and guides and to cause dangerous pounding. This may sometimes be the case, but is not necessary, can easily be avoided by proper design, and is no argument against the compound principle. Another speaker pointed out that any defect in a compound engine is usually cited as a proof that compounding is unsatisfactory, whereas it simply shows that the machine for utilizing the compound system is defective. It should be remembered that the economy of compounding is beyond dispute, but that it remains for locomotive builders and railway mechanical engineers to perfect the machines in which compounding is employed. In comparisons of simple and compound engines where a slight economy is shown for the latter, this may be due to the fact that the simple engines are worked very extravagantly. As to the experience of different railways, it was shown that a long series of tests covering several engines for several months showed an average ultimate economy of the compound of 26% on the Northern Pacific Ry. and 19% on the Atchison, Topeka & Santa Fe Ry. Mr. Buford (Am. Locomotive Co.) stated that the Grand Trunk Ry. has used cross-compound engines almost exclusively in freight service for the past six years, and is ordering additional engines of this class.